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GUN BLAST FROM NAVAL GUNS

by

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Test and Evaluation Department



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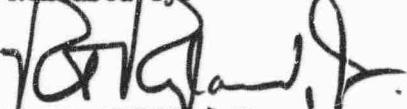
FOREWORD

The principal gun blast effort during the period covered by this report was concerned with the development of computer programs for curve fitting and data handling. This work included a mathematical model of the free-air gun blast field and a compilation of blast data for most calibers of naval guns. The computer programs developed are presently being used at the Naval Weapons Laboratory in connection with the reduction of all gun blast data.

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This report was reviewed by Messrs. F. F. Churchill, D. C. Ross, J. J. Yagla and Dr. G. R. Moore of the Instrumentation and Environments Division.

Released by:



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Acting Head, Test and
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ABSTRACT

The available data on gun blasts from naval guns are compiled utilizing computer curve fitting techniques. Curves of peak free-air pressure are presented for all naval guns, ranging in size from 20 mm to 16"/50. In addition, curves of arrival time, duration and impulse are given for three of these guns. Development of the computer programs and data reduction methods which were used to model the free-air gun blast field are described.

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INTRODUCTION

Gun blasts cause damage to ship and aircraft structures near the gun muzzle. In the past, parameters of the blast field near most Naval guns were measured, but the data had not been compiled in a systematic manner. The current work was undertaken to supply the information available on gun blast in a form that satisfies a long standing need. These data, when furnished to designers, should contribute to improvements in the design of structures to resist gun blast damage.

Individual readings of blast data must be organized into regular groupings such as blast curves. The collection of blast data was begun in 1905 with the introduction of a mechanical gauge called the Williams Blast Meter. These data were furnished in the form of blast curves which were widely distributed to shipyards and design activities. The Williams gauge 7 pound curve was formerly considered the limiting blast factor for structural and personnel damage, although the rationale for either use had not been well documented. The present effort provides the best available set of data on blast from naval guns. Some revision to the curves will be required when additional data are obtained.

The blast field around a gun is very similar to the shock field around explosives. However, the gun blast wave is produced by a large quantity of high pressure propellant gas having a high velocity along the axis of the gun. The large momentum component of the propellant gas along the gun axis leads to a pressure field that is asymmetrical about the muzzle plane.

Gun blasts sometimes exhibit other characteristics such as secondary blast. The secondary blast causes a second shock wave which follows the primary wave. Secondary blast is caused by certain powder formulations, the unburned propellant and gaseous products of which are ignited upon mixing with air. The newer, non-flashing propellants have significantly reduced the occurrence of secondary blast. The data supplied in this report neglect any secondary shocks and are only concerned with the primary free-air blast wave. Reflections of shock waves with decks or other surfaces are not analyzed or presented.

OBJECTIVE

The objective of this project was to develop a method for compiling gun blast data and presenting them in the form of pressure contours. The parameters considered most important to present were peak free-air pressure, arrival time, duration and impulse. These parameters describe the free-air blast field about the muzzle of a gun. Such knowledge is necessary before the reflected blast field about an actual gun installation may be determined.

PROCEDURES

The compilation of gun blast data began with a search of Naval Weapons Laboratory files for all available gun blast data and with the selection of those data which could be used. The principal effort was an attempt to mathematically model the blast field and to then generate the blast contours by using a computer. The final step in the compilation of data for each gun was the plotting of the contours, giving the blast field around the gun muzzle. The description of the process of developing the contours from the experimental data is detailed in the following paragraphs.

The data on gun blast which were available in the files included isolated measurements which were made for various purposes, often as secondary objectives on other tests. For most of these tests, the data were part of such an incomplete set they were usually bypassed in favor of more complete studies in which a large sector of the blast field was measured. These blast tests were usually conducted with the gun firing horizontally and the gauges mounted in the horizontal plane containing the gun. The data were usually taken at regular angles around the muzzle, such as 15, 30, 45, etc. degrees measured from the extended bore axis and muzzle of the gun.

For some guns it was not economical to fire at 0 degree elevation for the sole purpose of obtaining free-air gun blast data (the 16"/50 gun for example). In these cases, the gun was usually fired at a high angle of elevation. To be useful, the data measurement locations had to be transformed from ground coordinates to coordinates around the gun muzzle and bore axis extended. This procedure was considered valid since the free-air blast is assumed symmetrical about the gun axis.

The data for some guns were acquired recently and the oscillograph traces were still available. To prepare these data for subsequent tabulation, the records for each round were measured at several identifiable points on the record. Figure 1 shows a typical gun blast pressure trace and the idealized pressure wave as represented by the average wave.

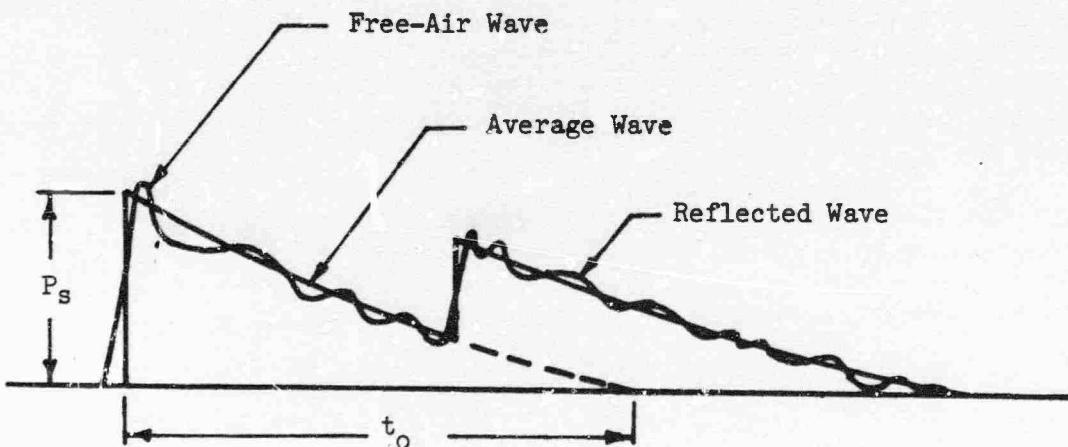


Figure 1. Typical Gun Blast Pressure Trace

The average wave can be represented by the Friedlander equation

$$P(t) = P_s (1 - t/t_o) e^{(-t/t_o)}$$

Where,¹

- $P(t)$ = Pressure at time t (psi)
- P_s = Peak pressure (psi)
- t = Time from the instant of shock arrival at the gauge (msec)
- t_o = Duration of the pressure above ambient (msec)
- e = 2.7183

¹In this report the term "pressure" means the pressure in excess of one atmosphere.

A computer program was used to assist in the data reduction and tabulation. This program was particularly useful in estimating the free-air duration in those cases in which the reflected wave partially obscured the free-air wave as shown in Figure 1. This was accomplished by measuring the free-air pressure just before the reflected wave occurred, and then having the program vary the duration in small increments until the Friedlander curve was found which best fit the average free-air wave. This method served to describe the wave completely since the impulse could be easily calculated from the fitted Friedlander equation. The balance of this discussion will outline the methods developed to use the data to obtain blast pressure contours.

The first step in modeling the free-air blast field was to assume the pressure followed an inverse power law along radial lines from the muzzle. This assumption was previously used in references 1 and 2 and has been found to closely approximate experimental data.

It was desired to describe the complete field of interest from the bore axis extended (0 degrees) to directly aft of the muzzle (180 degrees). This required that the experimental data be extrapolated to include regions where the experimental data coverage was incomplete.

The assumption that the pressure follows an inverse power law along radial lines from the muzzle implies that plotted values of experimental pressure vs distance on a log-log graph should appear as straight lines. The slope and intercept of each straight line is dependent upon the angle from the line of fire at which the measurements were made. Finding analytical expressions for the angular dependence of the slopes and intercepts is the essence of the mathematical modeling of the blast field.

Pressure vs distance was plotted on log-log graphs as shown in Figure 2. Straight lines were constructed which best fit the experimental data for each angle for which data existed.

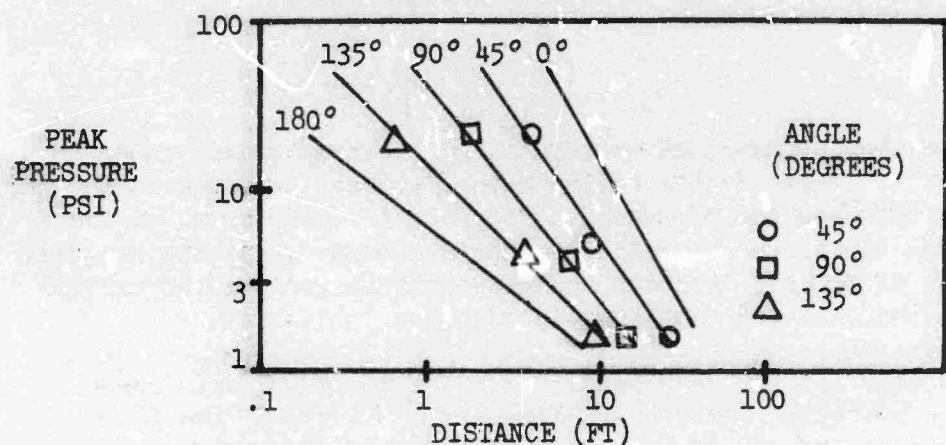


Figure 2. Typical Log-Log Graph of Pressure vs Distance

Additional lines, corresponding to angles for which experimental data did not exist, were drawn on the graph based on trends of the other lines and from scaling other caliber guns where data existed in these regions. The locations of some of the lines could be established from a single data point if adjacent lines were well defined. The log-log graph was then used to determine the radial distances from the muzzle at which 3 and 10 psi pressures existed for each of the thirteen radials that were chosen. The distances corresponding to the 3 and 10 psi pressures for the 13 angles were then plotted as shown in Figure 3. These contours were smoothed, as shown, to compensate for scatter in the data. The smoothed values of distance at the 13 chosen angles were then used as input to the curve fitting computer program, listed in Appendix B.

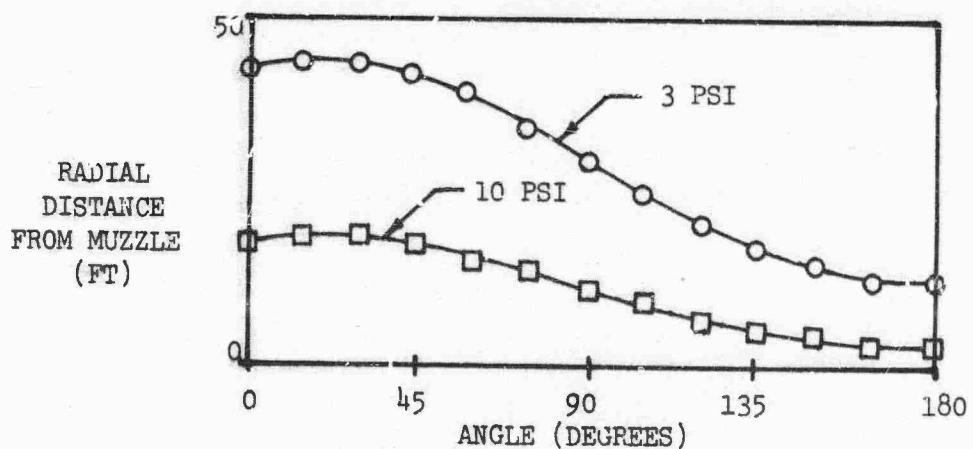


Figure 3. Typical 3 and 10 PSI Contours

The resulting contours as calculated by the program are shown in Figures 4 to 14. These smooth curves have also been modified to include experimental data and are repeated in Appendix A. Also shown on the curves in Appendix A are the calculated points computed by the program. The following paragraphs describe the mathematical formulation and computer program used in preparing the contours.

The computer program developed to compute the gun blast free-air peak pressure contours is listed in Appendix B along with its flow chart. It uses a standard orthonormal polynomial fit subroutine which has also been listed in Appendix B. A description of the computer program follows.

The first step in the computer program was to curve fit the 3 and 10 psi contours which were entered at 13 angles around the muzzle. This was done in an attempt to further smooth the contours.

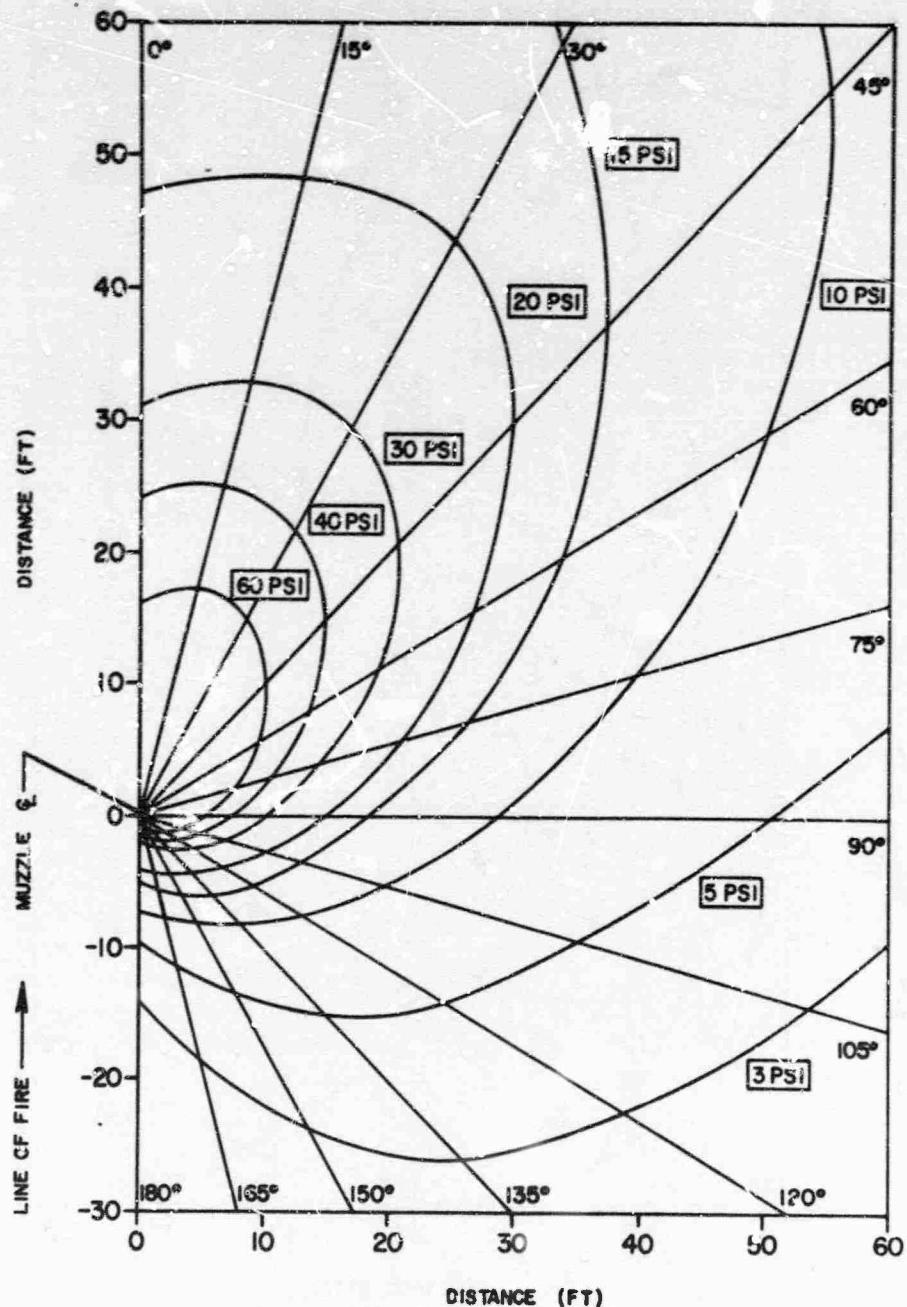
As noted earlier, the peak pressure was assumed to decrease as the inverse power of distance. This can be written as follows for each angle:

$$P_s = AD^{-N} \quad (1)$$

where

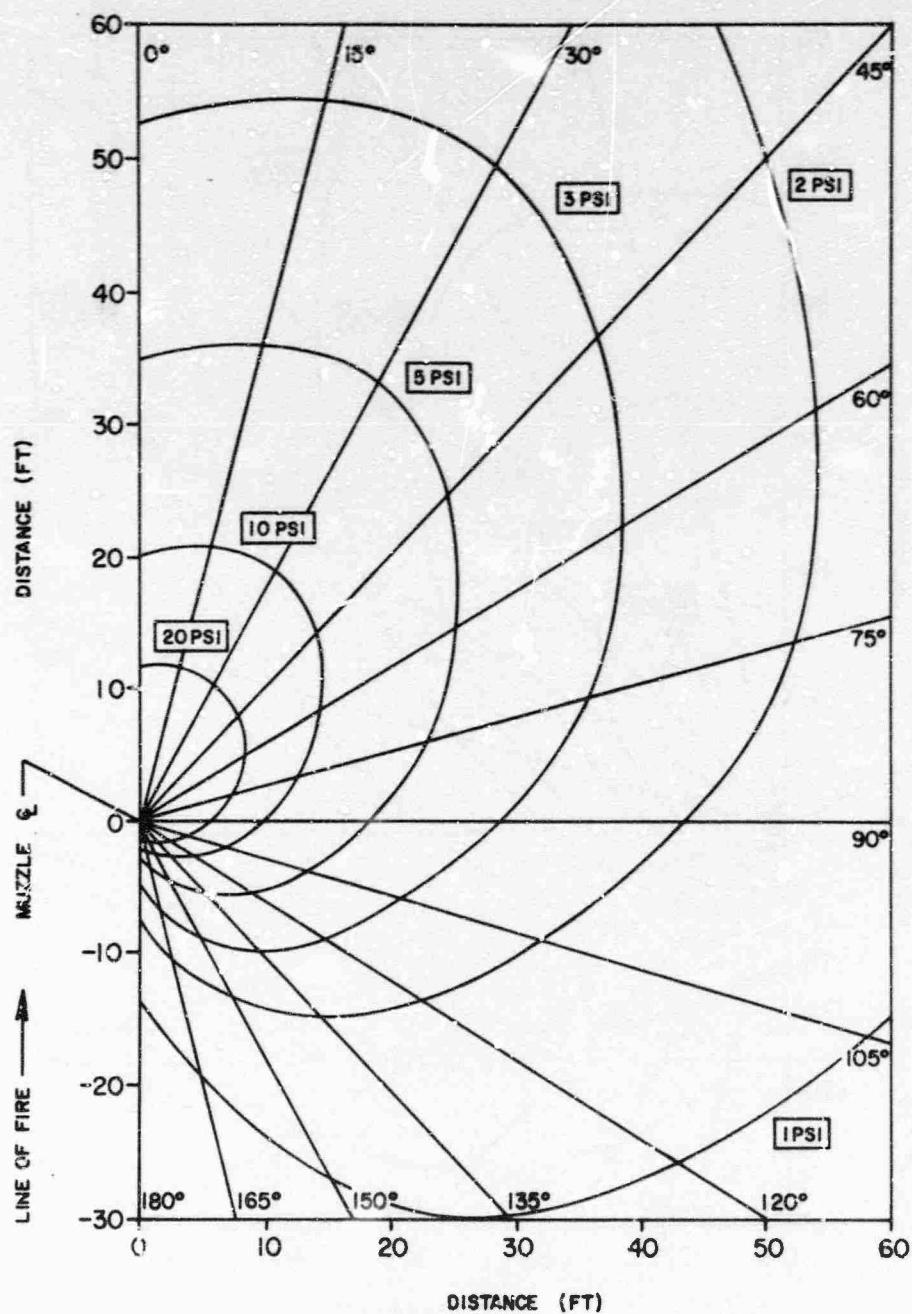
- P_s = peak pressure (psi)
- D = distance (ft)
- A = constant
- N = constant

The constant, $-N$, is the slope of the pressure vs distance curve when plotted on a log-log graph as shown in Figure 15.



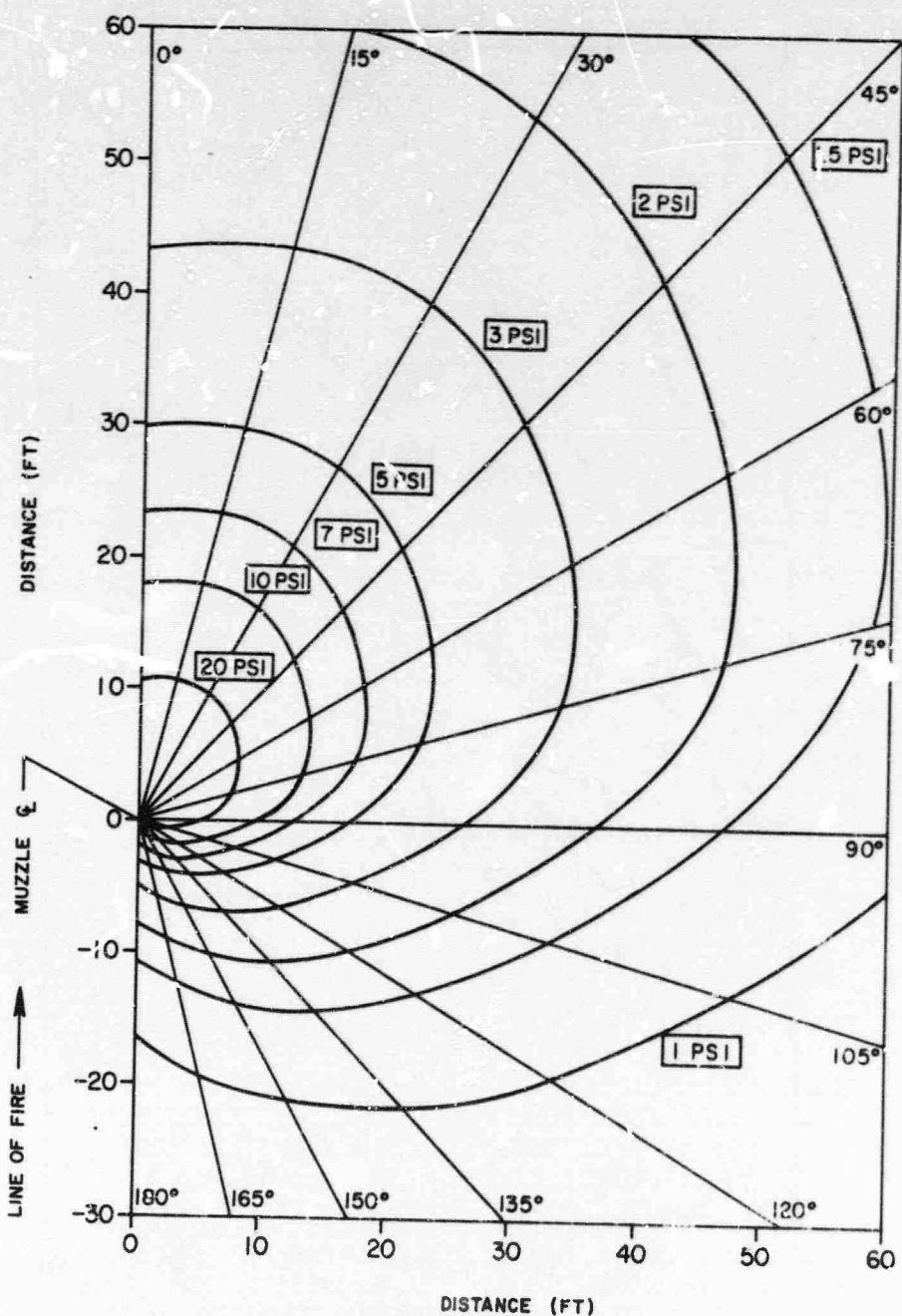
FREE-AIR PEAK PRESSURE CURVES FOR 16"/50 GUN

FIGURE 4



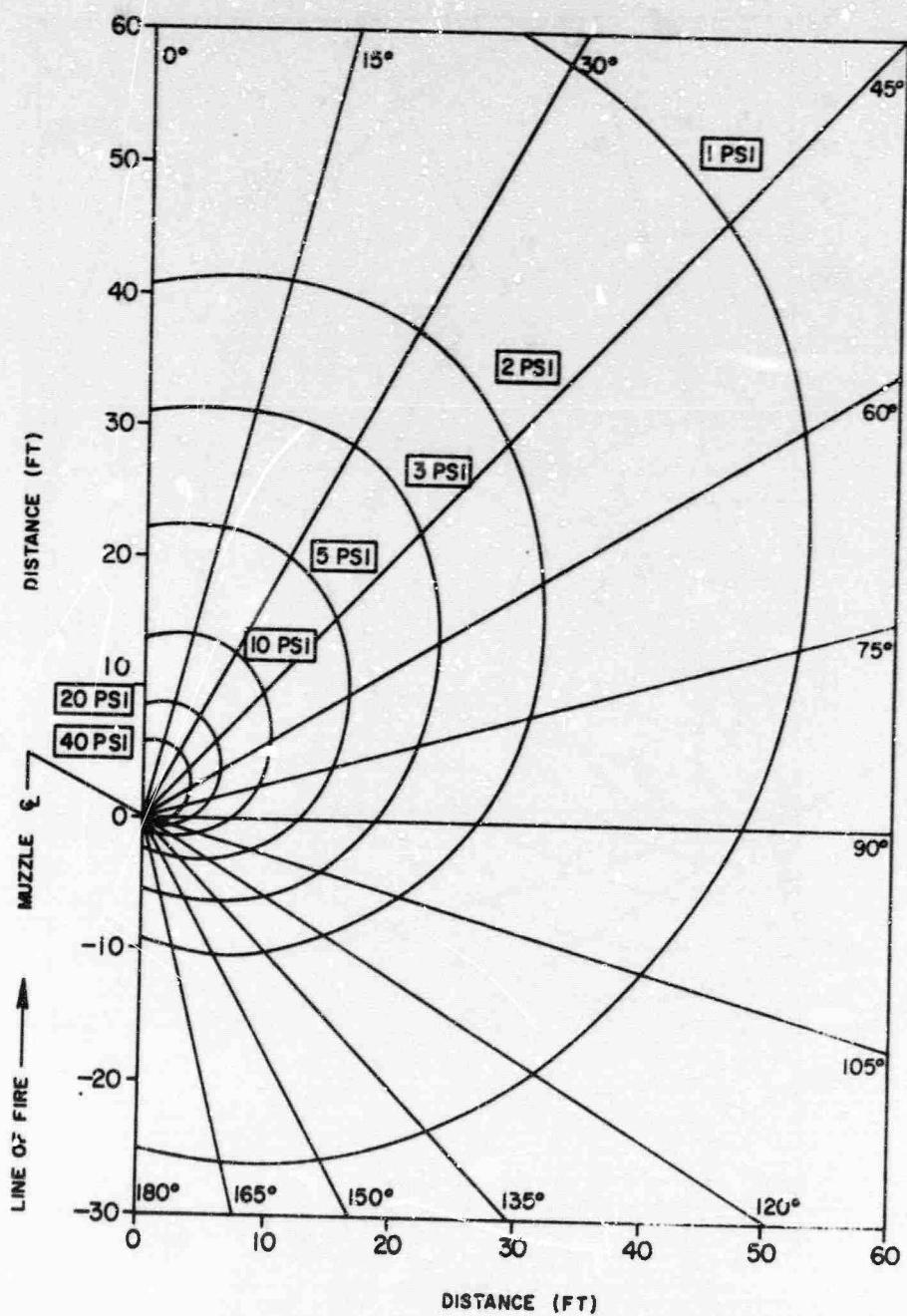
FREE-AIR PEAK PRESSURE CURVES FOR 8"/55 GUN

FIGURE 5



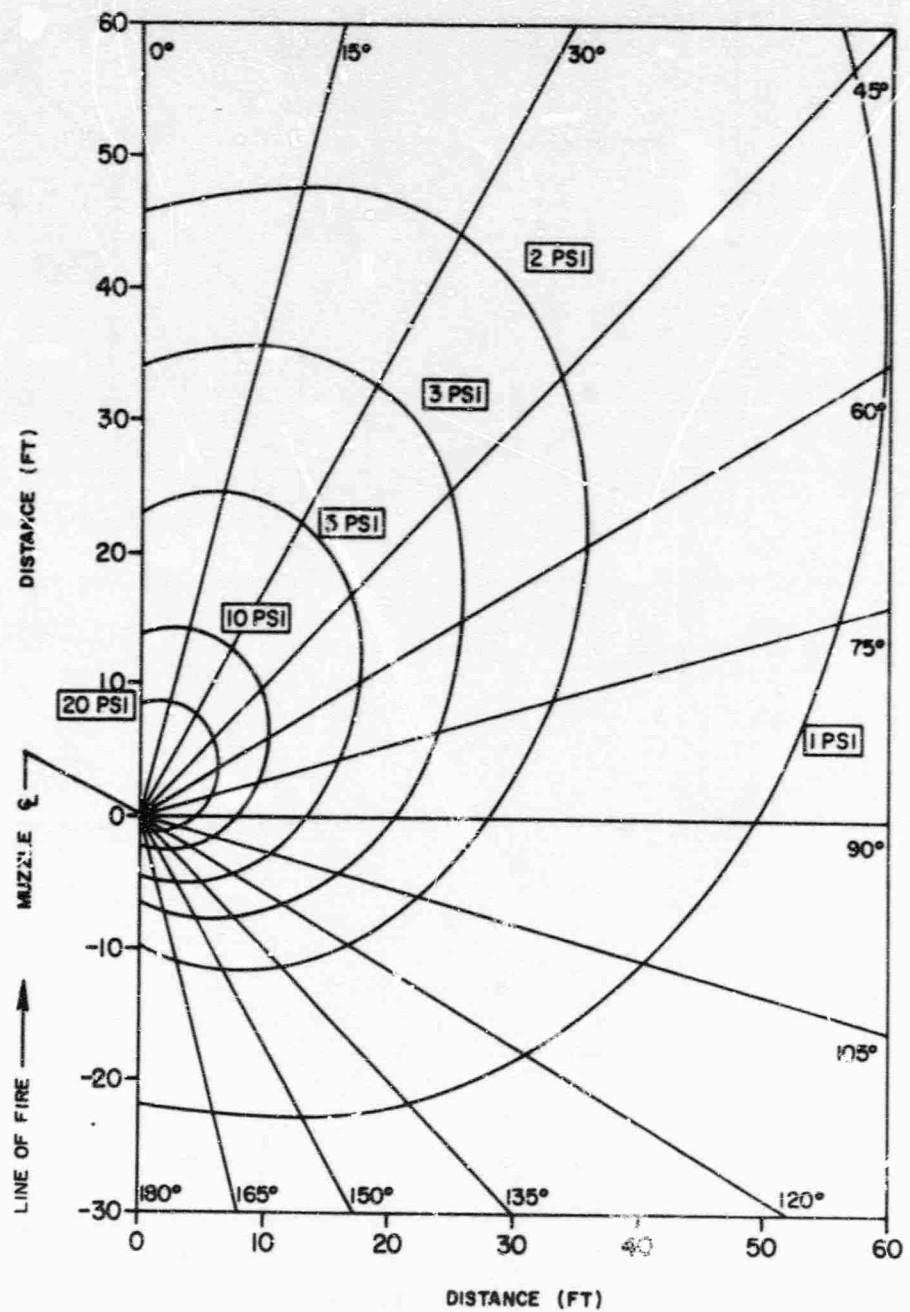
FREE-AIR PEAK PRESSURE CURVES FOR 6"/47 GUN

FIGURE 6



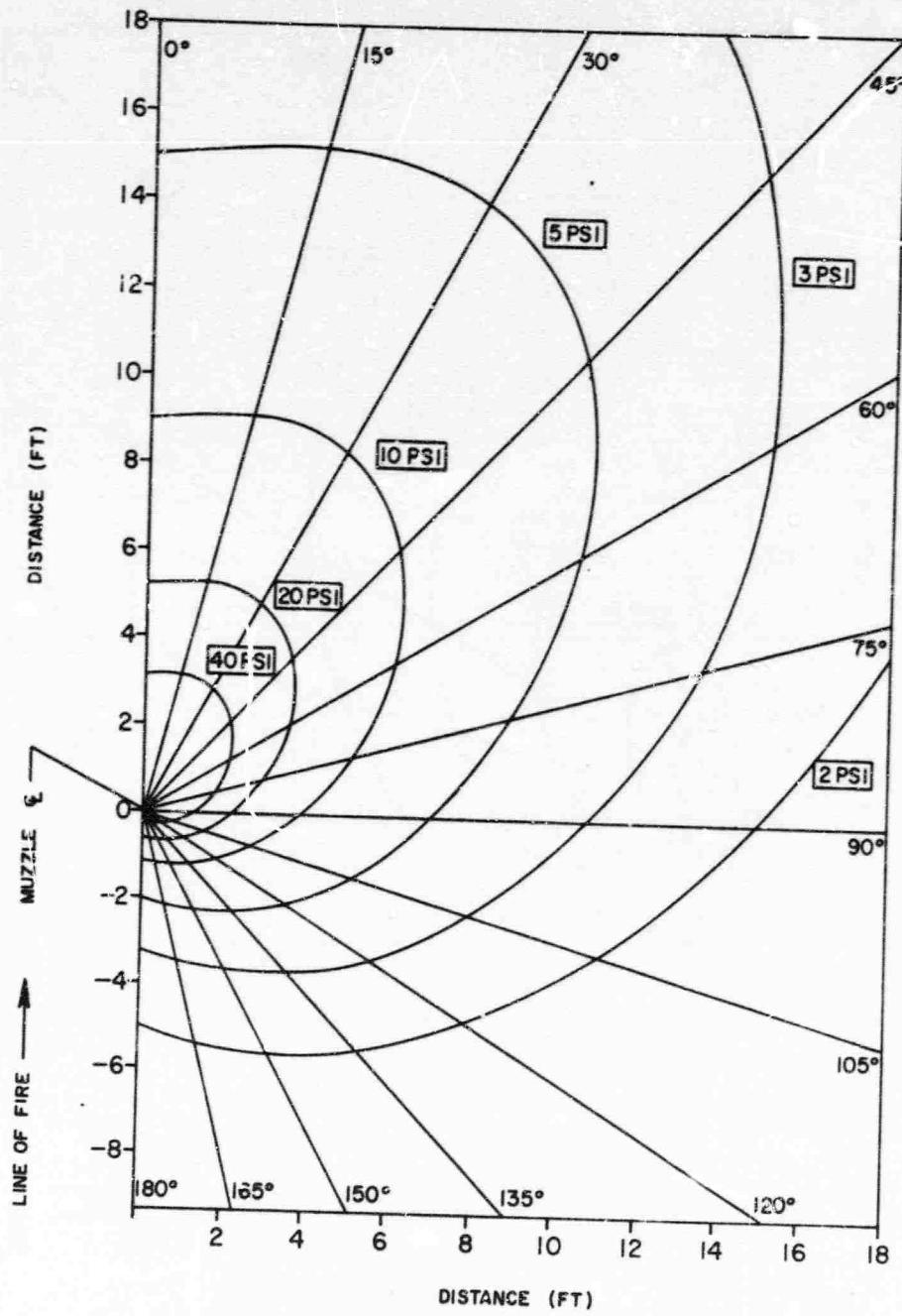
FREE-AIR PEAK PRESSURE CURVES FOR 5"/54 GUN

FIGURE 7



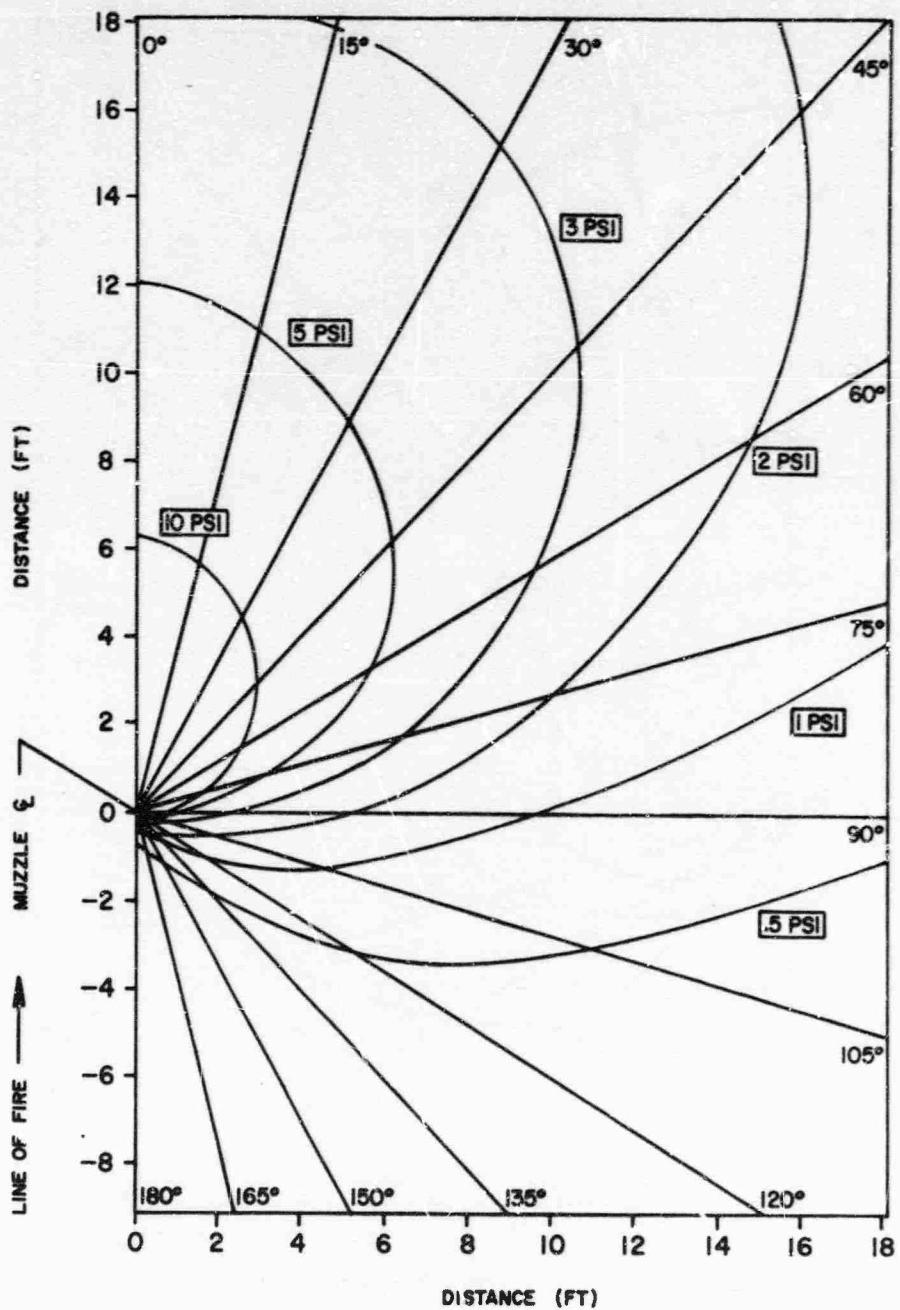
FREE-AIR PEAK PRESSURE CURVES FOR 5"/38 GUN

FIGURE 8



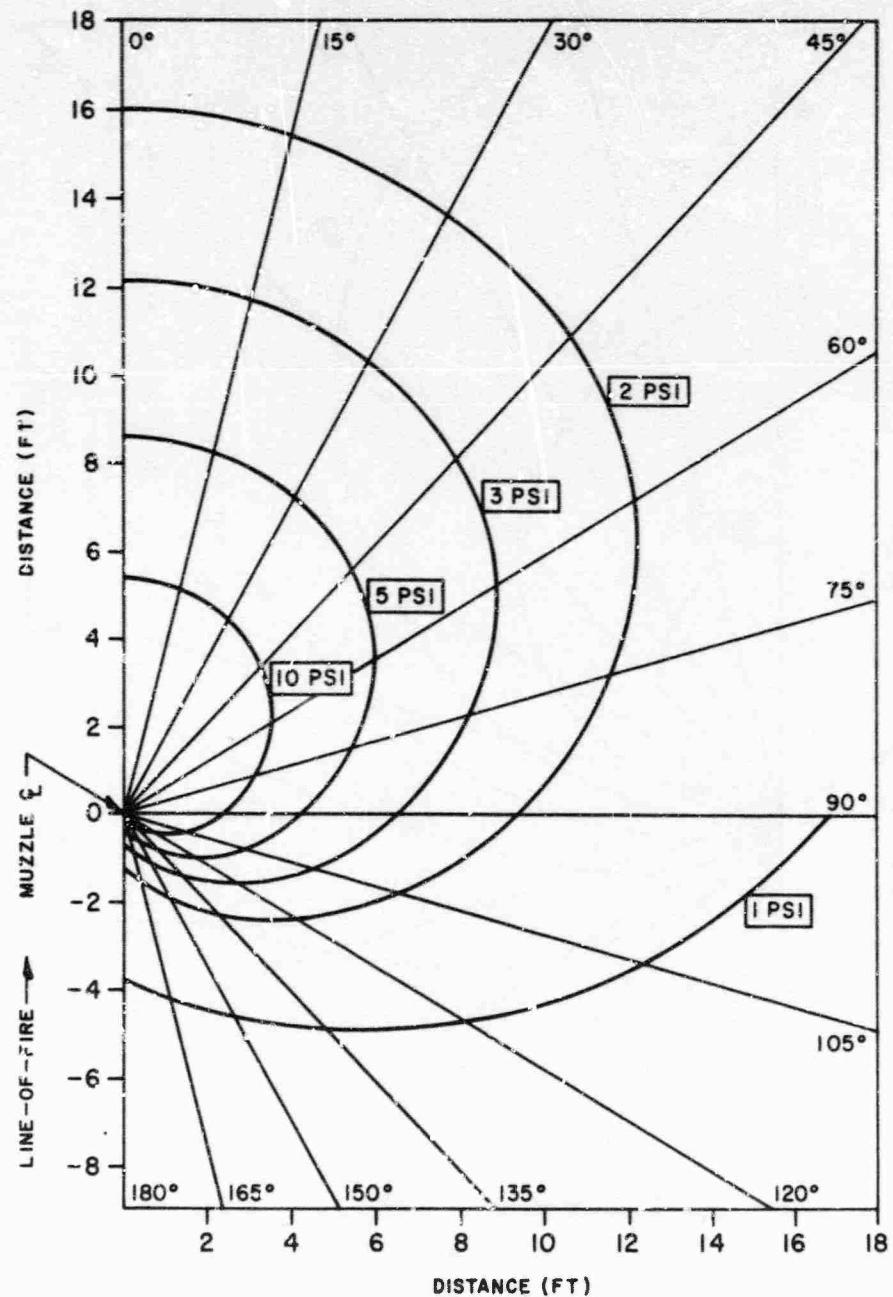
FREE-AIR PEAK PRESSURE CURVES FOR 3"/50 GUN

FIGURE 9



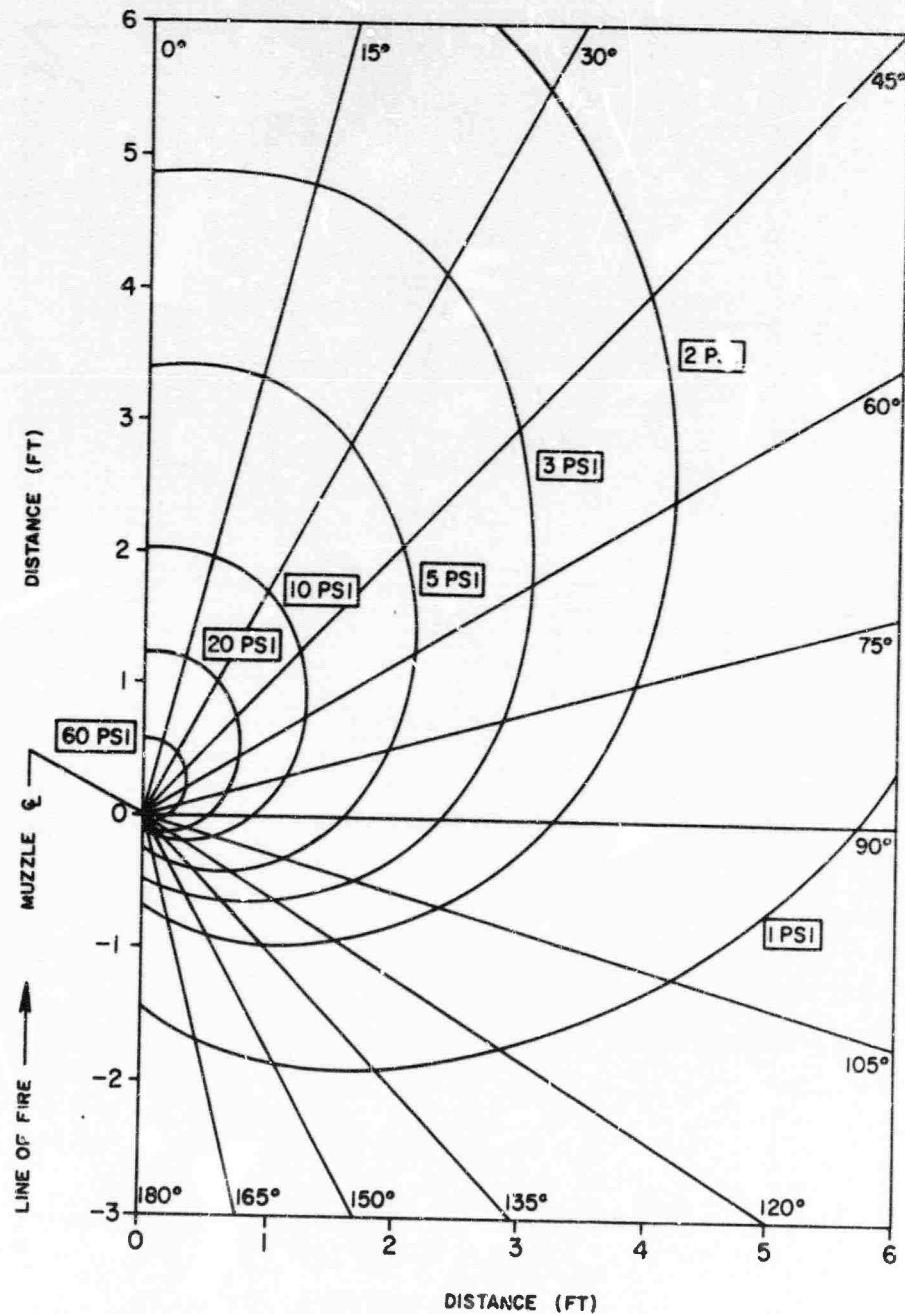
FREE-AIR PEAK PRESSURE CURVES FOR
40 MM GUN WITH FLASH HIDER

FIGURE 10



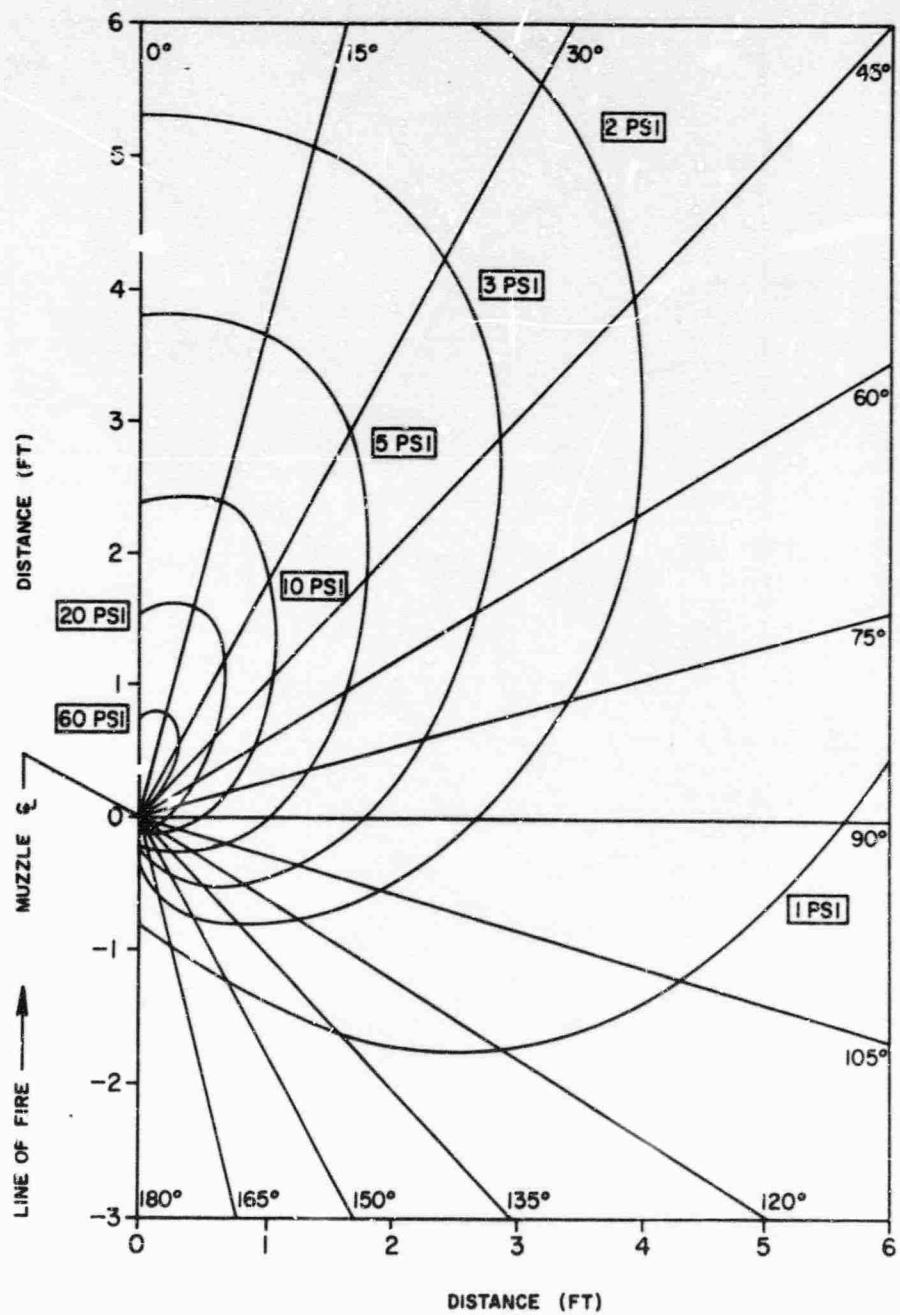
FREE-AIR PEAK PRESSURE CURVES FOR
40 MM GUN WITHOUT FLASH HIDER

FIGURE II



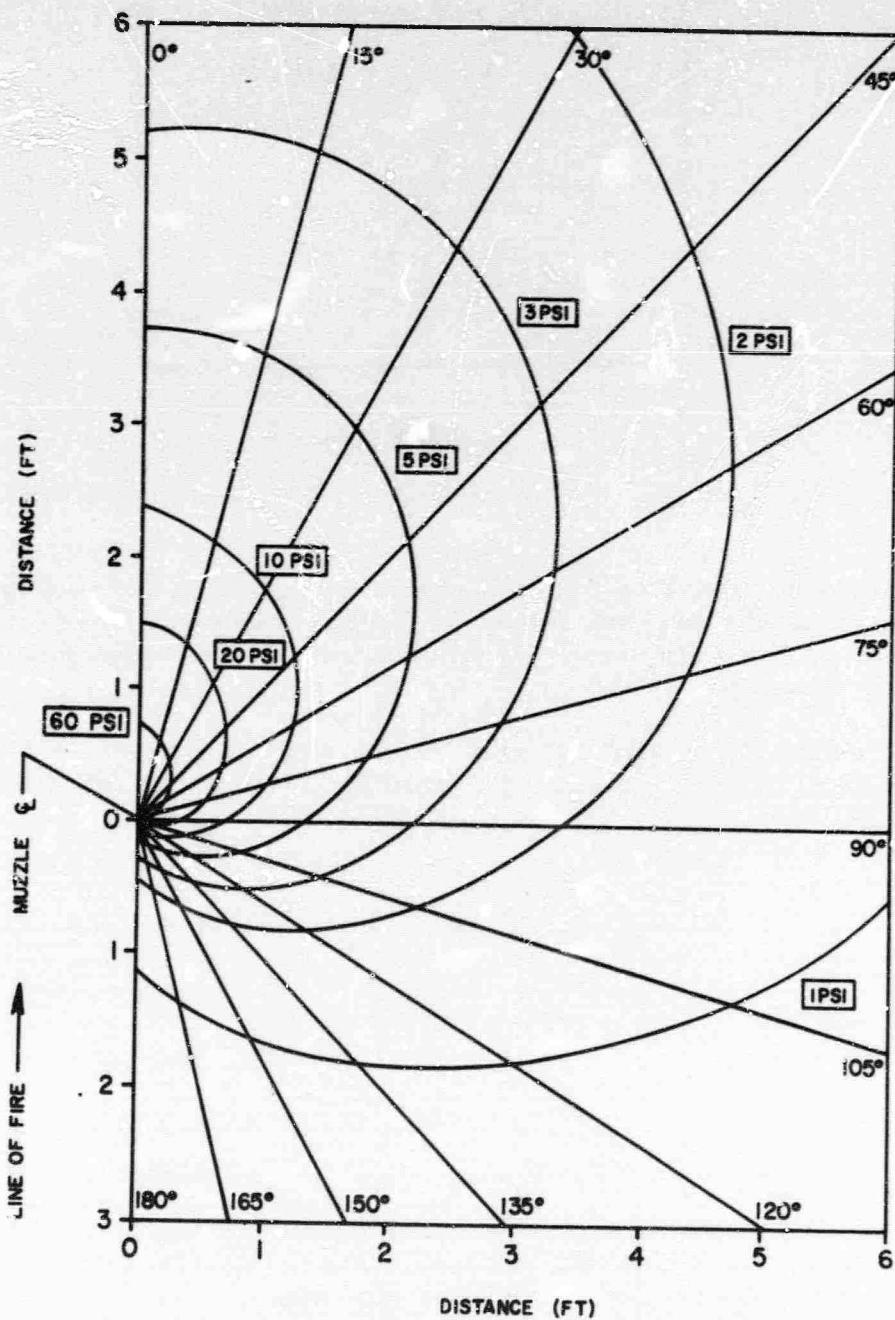
FREE-AIR PEAK PRESSURE CURVES FOR 20 MM M3 GUN

FIGURE 12



FREE-AIR PEAK PRESSURE CURVES FOR 20 MM XM 197 GUN

FIGURE 13



FREE-AIR PEAK PRESSURE CURVES FOR 20 MM MK12 GUN

FIGURE 14

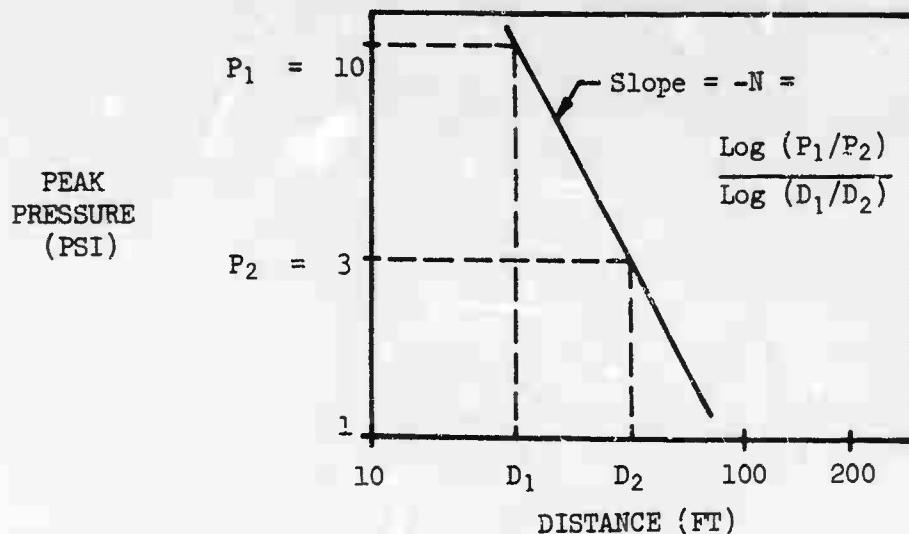


Figure 15. Log-Log Graph of Peak Pressure vs Distance and Definition of N

The values of the constants N are then calculated for each of the 13 angles from the smoothed values of distance corresponding to the 3 and 10 psi pressure contours. Next, equation (1) is solved for A, giving 13 values for A.

The constants A and N are next fitted with polynomials in terms of the angle, χ , measured from the extended bore axis and muzzle, giving

$$A = A_1 + A_2 \chi + A_3 \chi^2 + \dots + A_9 \chi^8 \quad (2)$$

$$N = N_1 + N_2 \chi + N_3 \chi^2 + \dots + N_9 \chi^9 \quad (3)$$

where A_1, A_2, \dots, A_9 and N_1, N_2, \dots, N_9 are the coefficients of the polynomial fits of the constants A and N. Substitution of the polynomials given by equations (2) and (3) into equation (1) completely describes the free-air peak pressure field about the gun muzzle.

$$P(D, \psi) = \left(\sum_{i=1}^9 A_i \psi^{i-1} \right) \left(D \sum_{i=1}^9 N_i \psi^{i-1} \right) \quad (4)$$

In Figures 16 and 17, typical graphs of the constants N and A have been shown as functions of muzzle angle. X.

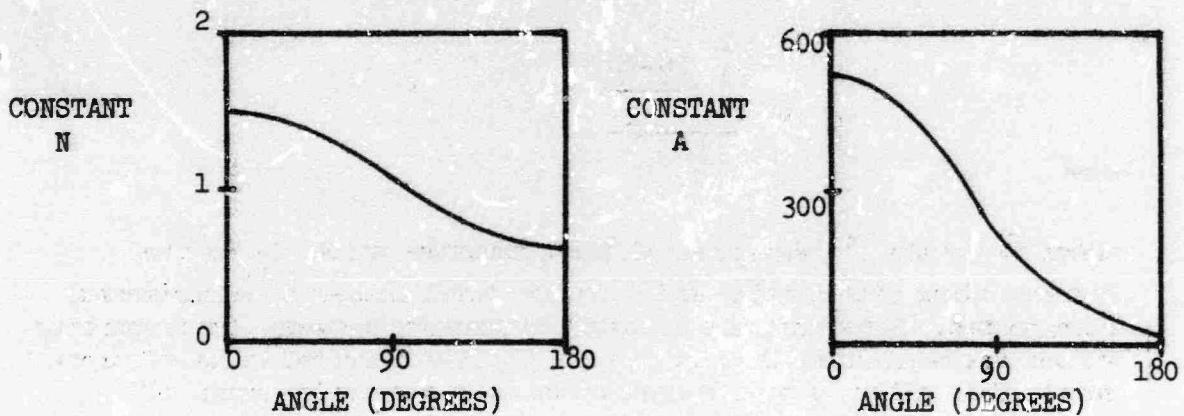


Figure 16. Typical Graph of Constant N vs Angle

Figure 17. Typical Graph of Constant A vs Angle

Graphs of the constants A and N were constructed for all of the guns investigated in this report. They were used as a further check on the consistency between guns in regions around the gun muzzle where insufficient data existed.

After the computer program has calculated the coefficients for equations (2) and (3), the distances to the 3 and 10 psi pressures at the 13 regular angles are calculated using equation (4). This provides a direct comparison between the original values which were put into the computer program and the calculated values.

Next the program computes 21 contours ranging from .1 to 2000 psi pressure. These are provided as distances from the muzzle to each contour along each of the 13 angles.

Next all the experimental data are introduced. Each experimental pressure reading together with its free-air angle and distance are provided as input. Using the coefficients previously calculated, the program computes a pressure at the same location and compares it with the corresponding experimental value. Two statistical values are calculated for comparison purposes.

A normalized first moment, v_1 , is calculated as given by

$$v_1 = \frac{\sum_{i=1}^k \frac{P_i - \bar{P}_i}{P_i}}{K}, \quad (5)$$

where \bar{P}_i is the i^{th} experimental peak pressure value, P_i is the corresponding fitted value and K is the total number of experimental data points. Note that the pressure difference between corresponding values has been normalized by dividing by the computed value of pressure. This allows a statistical check over the entire range of pressures.

The square root of the normalized second moment, v_2 , given by,

$$v_2 = \sqrt{\frac{\sum_{i=1}^k \frac{(P_i - \bar{P}_i)^2}{P_i}}{K}}, \quad (6)$$

is also computed. The statistical computations for each gun are listed in Appendix E. The experimental data used in calculating the statistical values also included round-to-round variations in the experimental data. Therefore, the statistical values as given in Appendix E are not completely indicative of the accuracy of the fitting method since they also include variations in the experimental data.

The method developed to provide pressure contours was also used for arrival time, duration and impulse with no changes in the program, even though the slopes were positive in some cases.

RESULTS

The free-air gun blast curves presented in this report represent an accumulation of data taken over many years at the Naval Weapons Laboratory. Firing test data including date; Mark-Mod; propellant

type, index and weight; and projectile Mark and weight are listed in Appendix F. On tests where this information was not recorded or was not to be found, it has been indicated as "not available".

The small caliber guns such as the 20 mm have many configurations. Three 20 mm guns are presented in this report. Detailed records of small caliber gun tests are not permanently filed at NWL. Therefore, the firing test data for these guns are listed in Appendix F.

The free-air peak pressure curves are given in the body of this report as Figures 4 to 14 and a copy of each of these curves containing additional information is provided in Appendix A. For the 8"/55, 5"/54 and 3"/50 guns, preliminary curves giving the other parameters of arrival time, duration and impulse are also included in Appendix A. The dashed lines on the graphs in Appendix A enclose the areas in which experimental data were available. The experimental data points are shown by the square symbols to indicate the location of the measurement. The value of the experimental measurement is placed beside the symbol. The round symbols on the curves indicate the fitted data point locations as computed by the curve fitting program.

The experimental data which were used in constructing the log-log graph and in the statistical calculations are listed in Appendix C. Digital values for the contours which were generated by the curve fitting program are provided in Appendix D. This list is included since it contains a greater range of pressures than is shown on the graphs.

DISCUSSION OF RESULTS

The contour fitting technique described in this report was found to work well for determining the gun blast contours of peak pressure using experimental data. This technique allows a systematic determination of the complete gun blast pressure field with a limited amount of experimental data. The assumption that the peak pressure decays as an inverse power law along radial lines from the muzzle agrees well with experimental data over the ranges of pressure listed in Appendix C.

The shock wave arrival time data were also found to closely approximate the assumed radial decay. However, a common ejection or reference time has not been used in most gun blast tests. Thus the data presented may be shifted in time depending upon the method used to measure ejection time of the projectile. For this reason curves of arrival time have been marked "preliminary" although the discrepancy does not effect the accuracy of the shape of these curves, but will only shift the time increments slightly (less than 1 millisecond).

The contour fitting technique was also applied to duration and impulse gun blast data from the 8"/55, 5"/54 and 3"/50 guns. Both duration and impulse gun blast data contain considerable scatter due primarily to the method by which the data were taken. Reflections of the blast wave from the ground, gun mount and other structures are superimposed on the free-air wave making it difficult to determine the precise duration or impulse of the free-air blast wave. For this reason it was not possible to completely evaluate the assumption that duration and impulse follow an inverse power law along radial lines from the muzzle. Therefore the contour graphs of duration and impulse have also been labeled "preliminary".

The statistical comparison between the computed contours and experimental data is given in Appendix E. Although these values also include round-to-round variations in the experimental data, the fit is in general quite good for both peak pressure and arrival time. The 16"/50, 20 mm M3 and 20 mm XM197 guns show somewhat more variation, but this is primarily due to scatter in the experimental data and particularly the lack of data in the case of the 16"/50 gun.

CONCLUSIONS

A large body of experimental gun blast data have been systematically analyzed and presented. The contour fitting computer program and methods of data handling which were developed under this research project provide a means of translating experimental data readings into useful graphs and tables.

The free-air gun blast curves presented were computed from the best currently available gun blast data. As new and more extensive experimental data become available, the techniques presented in this report may be used to compute new and more accurate free-air gun blast contours.

REFERENCES

- (1) M. Walther "Gun Blast From A 5"/54 Gun" Naval Proving Ground, Dahlgren, Virginia, Report No. 1608 dated 30 July 1958.
- (2) M. Walther "Blast Studies; Gun Blast From a 5"/38 Gun" Naval Proving Ground, Dahlgren, Virginia, Report No. 1307 dated 26 Nov 1954.

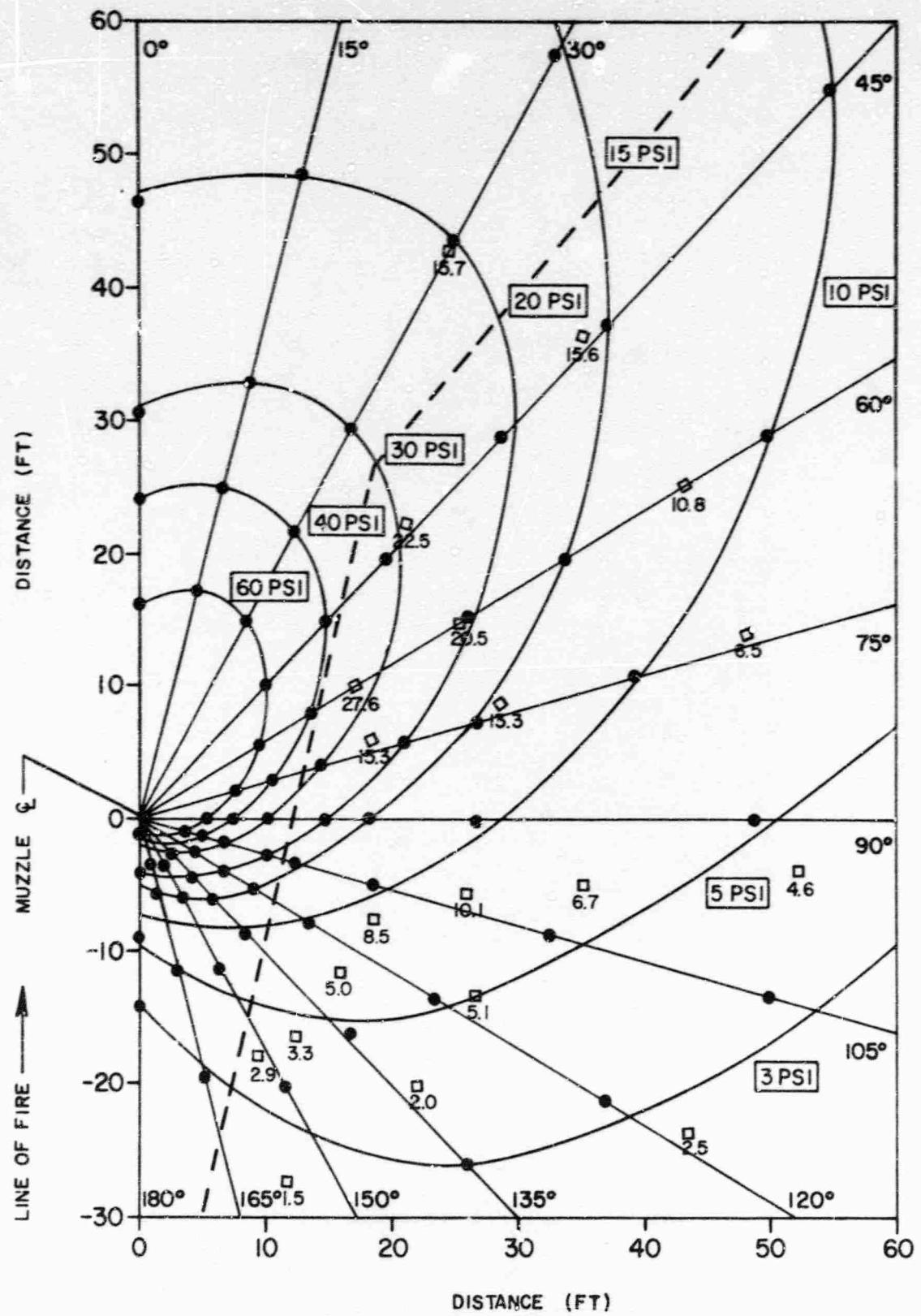
APPENDIX A

**GUN BLAST CURVES WITH EXPERIMENTAL
DATA AND COMPUTER GENERATED POINTS**

APPENDIX A

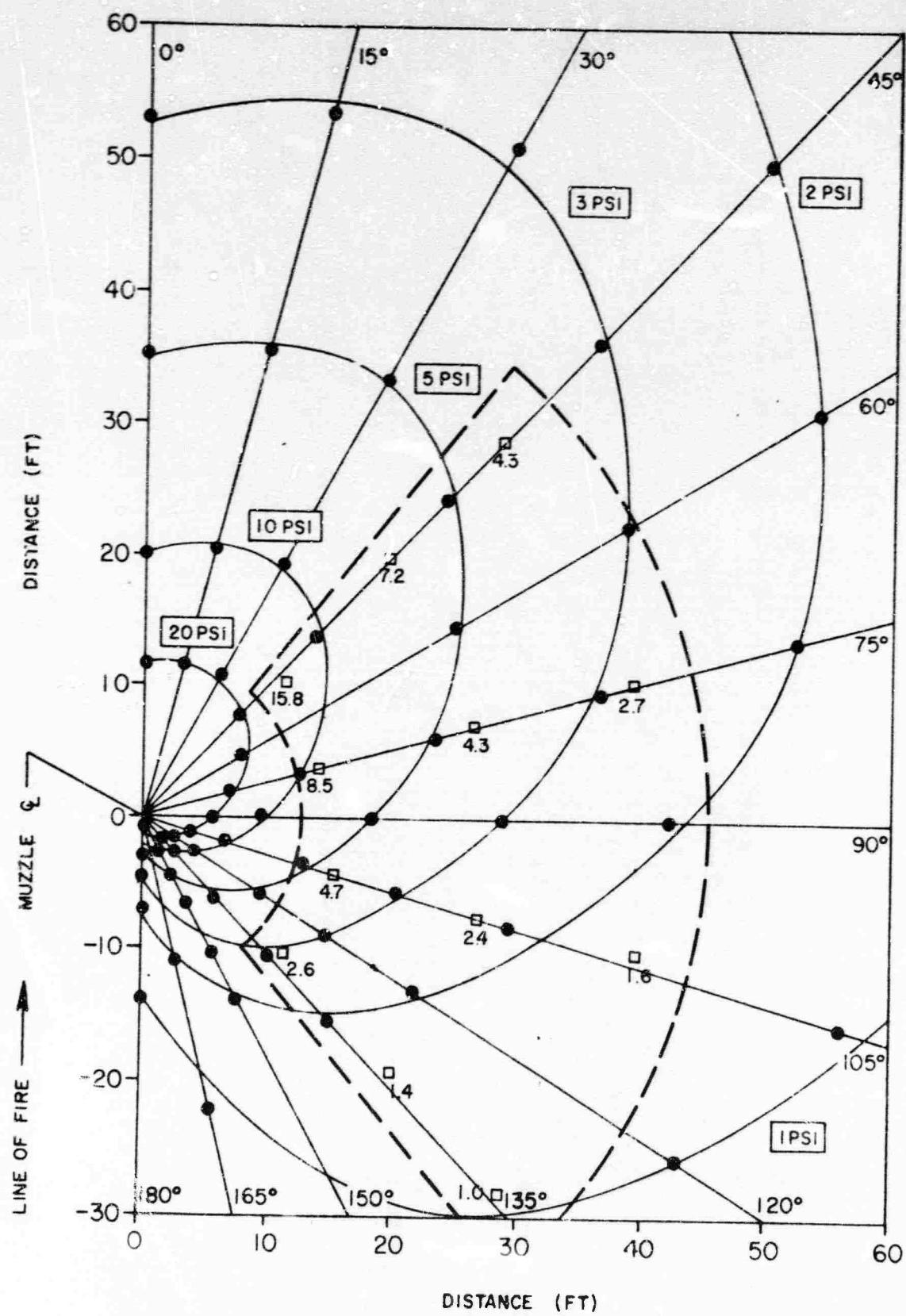
GUN BLAST CURVES WITH EXPERIMENTAL DATA AND COMPUTER GENERATED POINTS

- Figure A-1 Free-Air Peak Pressure Curves for 16"/50 Gun
A-2 Free-Air Peak Pressure Curves for 8"/55 Gun
A-3 Free-Air Arrival Time Curves for 8"/55 Gun (preliminary)
A-4 Free-Air Duration Curves for 8"/55 Gun (preliminary)
A-5 Free-Air Impulse Curves for 8"/55 Gun (preliminary)
A-6 Free-Air Pressure Curves for 6"/47 Gun
A-7 Free-Air Pressure Curves for 5"/54 Gun
A-8 Free-Air Arrival Time Curves for 5"/54 Gun (preliminary)
A-9 Free-Air Duration Curves for 5"/54 Gun (preliminary)
A-10 Free-Air Impulse Curves for 5"/54 Gun (preliminary)
A-11 Free-Air Pressure Curves for 5"/38 Gun
A-12 Free-Air Peak Pressure Curves for 3"/50 Gun
A-13 Free-Air Arrival Time Curves for 3"/50 Gun (preliminary)
A-14 Free-Air Duration Curves for 3"/50 Gun (preliminary)
A-15 Free-Air Impulse Curves for 3"/50 Gun (preliminary)
A-16 Free-Air Peak Pressure Curves for 40 mm Gun With Flash Hider
A-17 Free-Air Peak Pressure Curves for 40 mm Gun Without Flash Hider
A-18 Free-Air Peak Pressure Curves for 20 mm M3 Gun
A-19 Free-Air Peak Pressure Curves for 20 mm XM 197 Gun
A-20 Free-Air Peak Pressure Curves for 20 mm MK 12 Gun



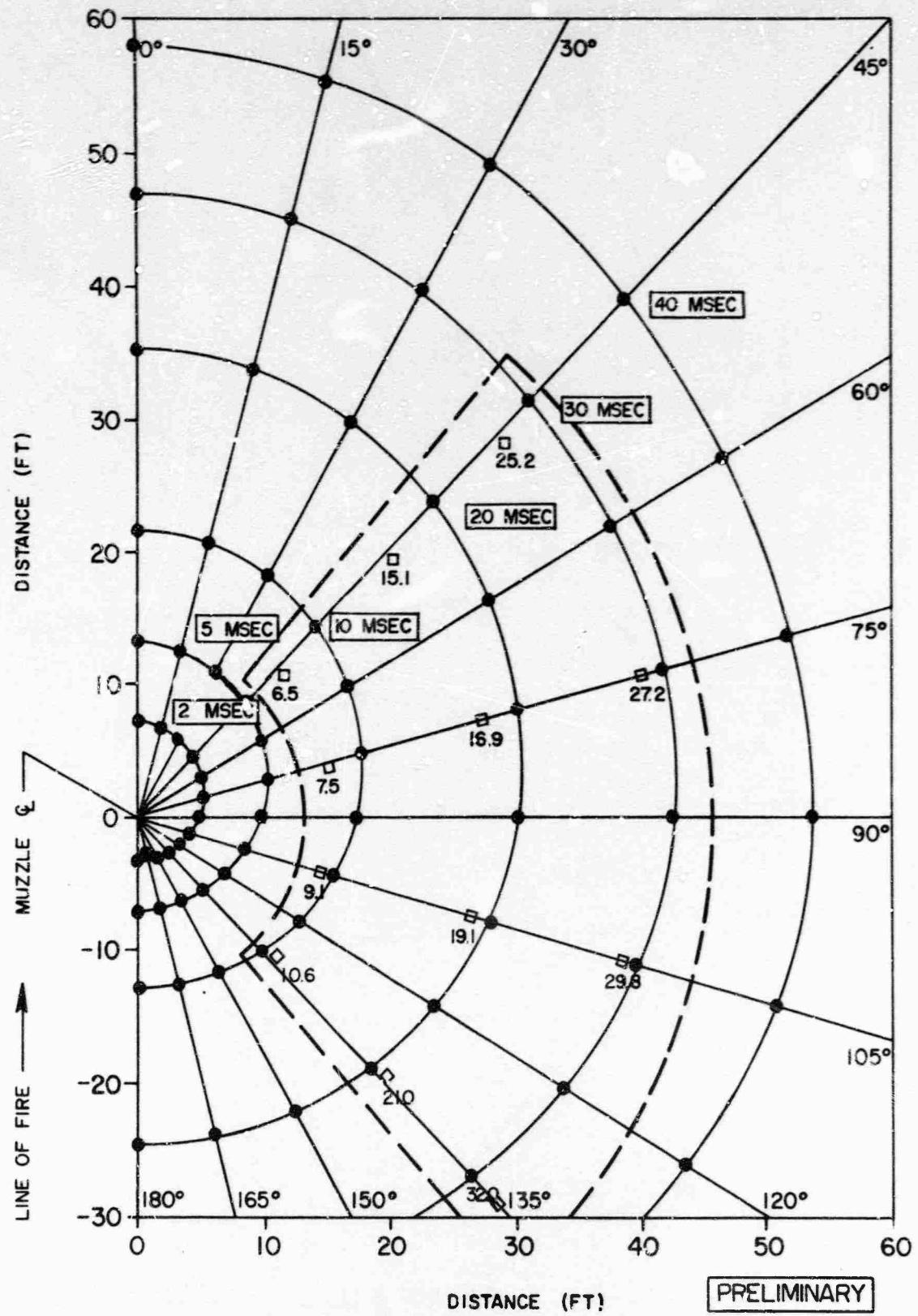
FREE-AIR PEAK PRESSURE CURVES FOR 16"/50 GUN

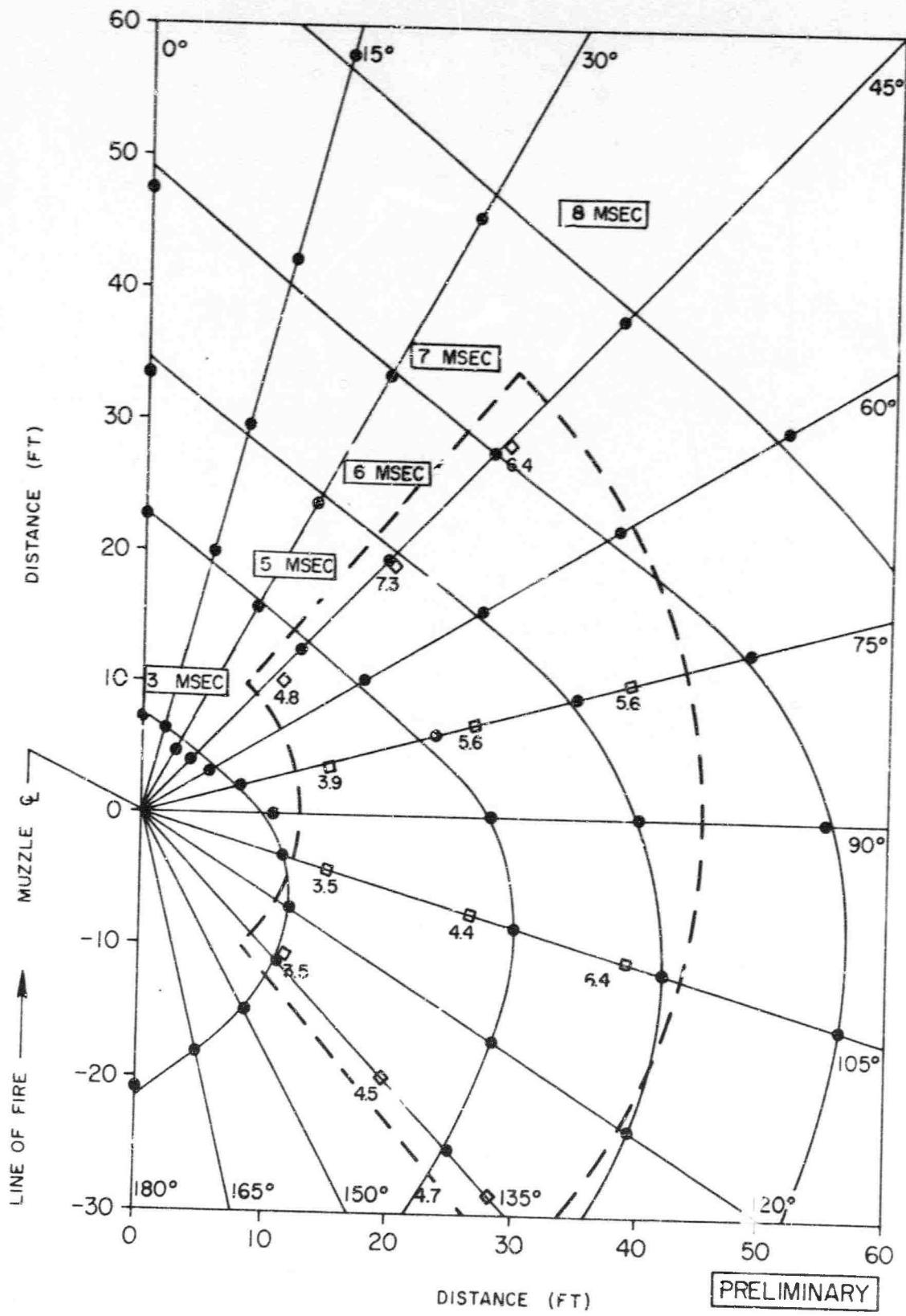
FIGURE A-1



FREE-AIR PEAK PRESSURE CURVES FOR 8"/55 GUN

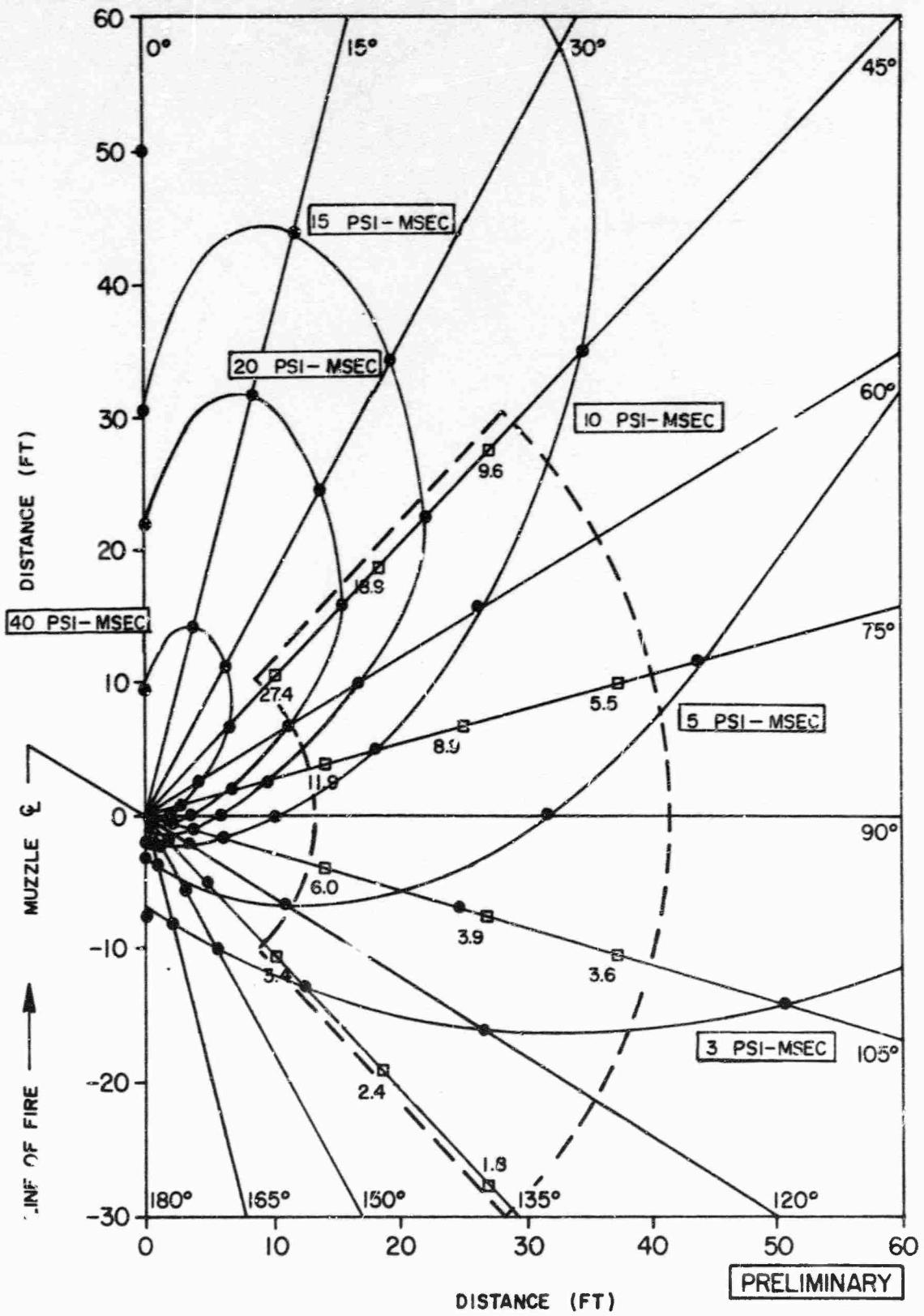
FIGURE A-2





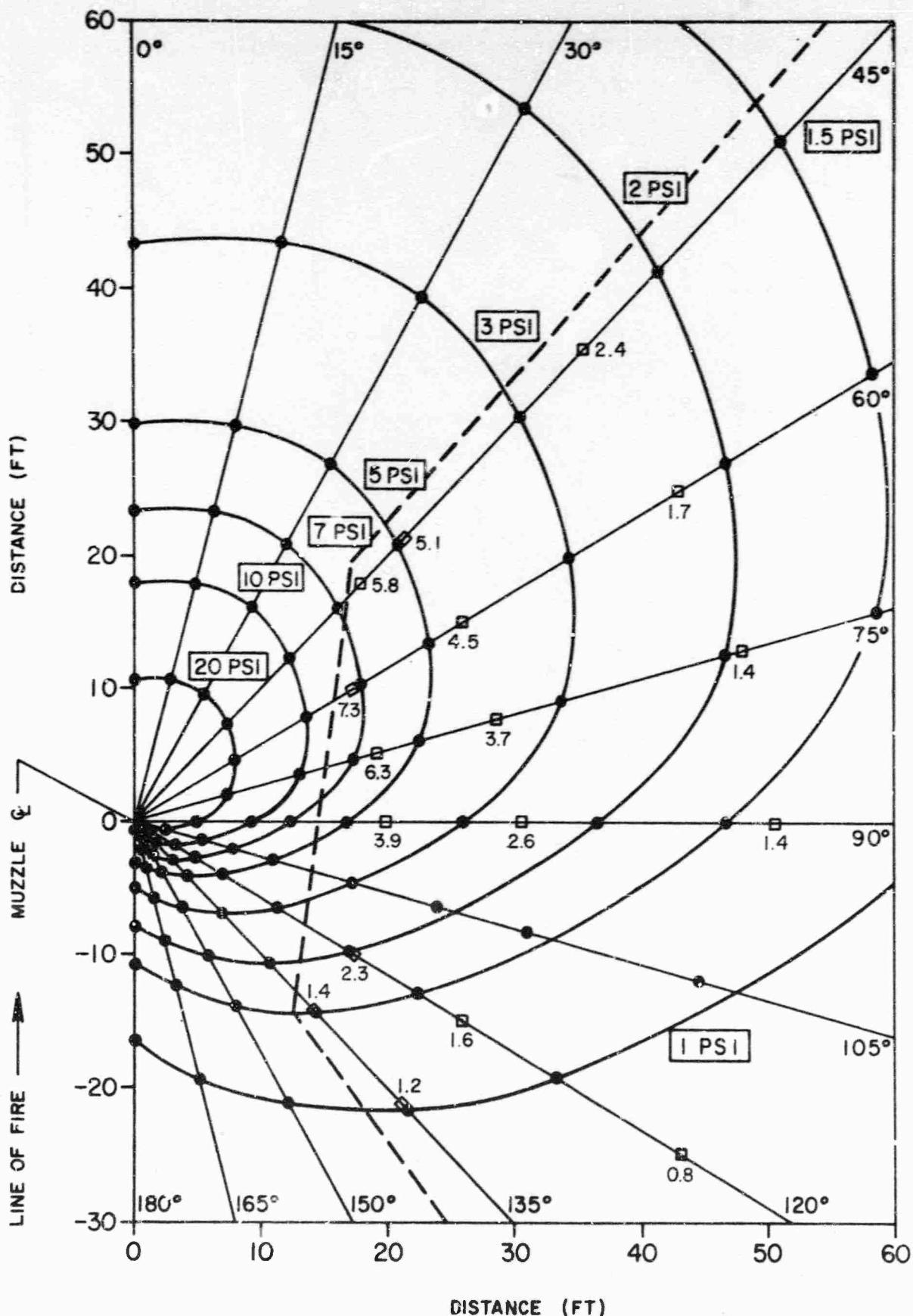
FREE-AIR DURATION CURVES FOR 8"/55 GUN

FIGURE A-4



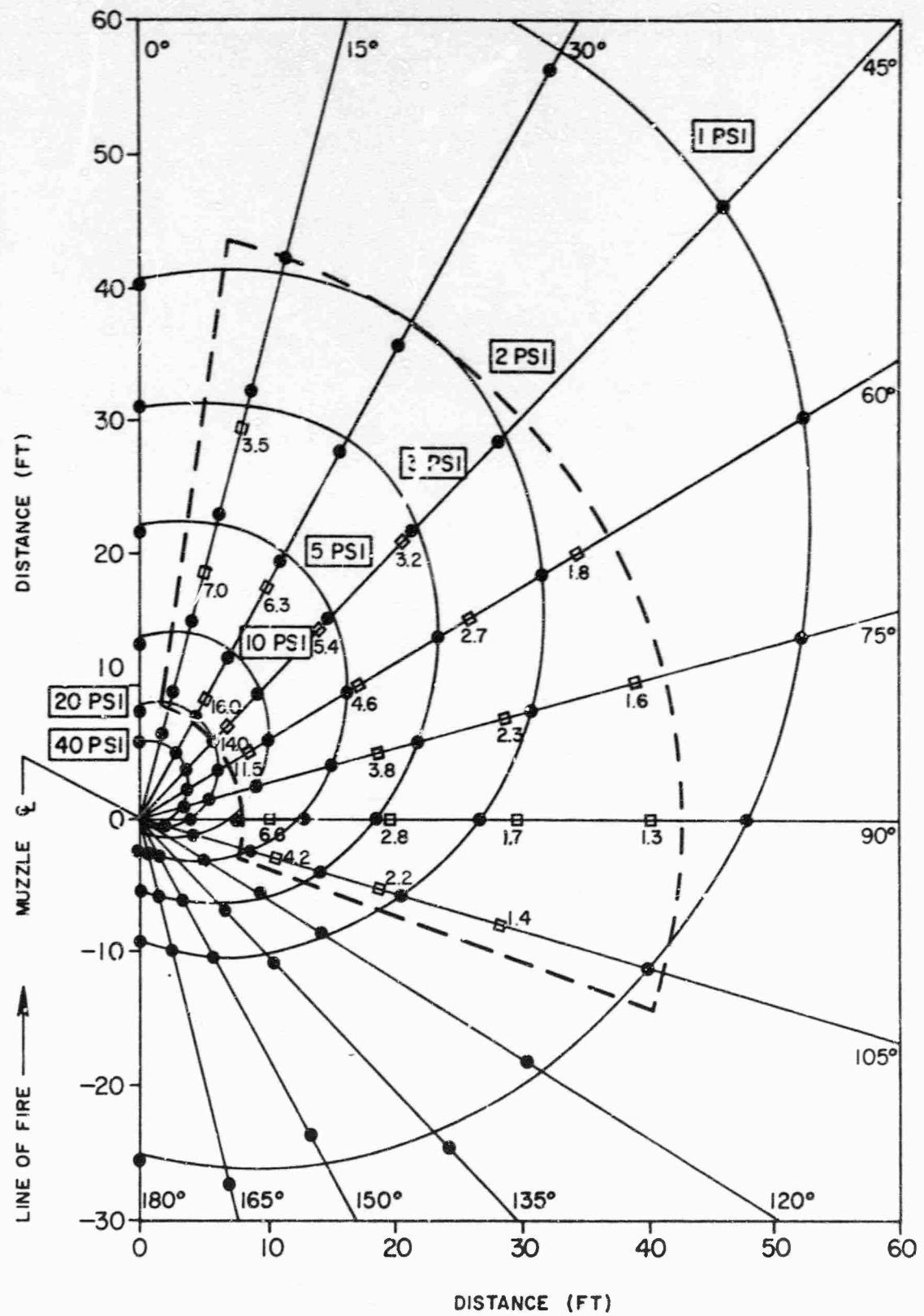
FREE-AIR IMPULSE CURVES FOR 8"/55 GUN

FIGURE A-5



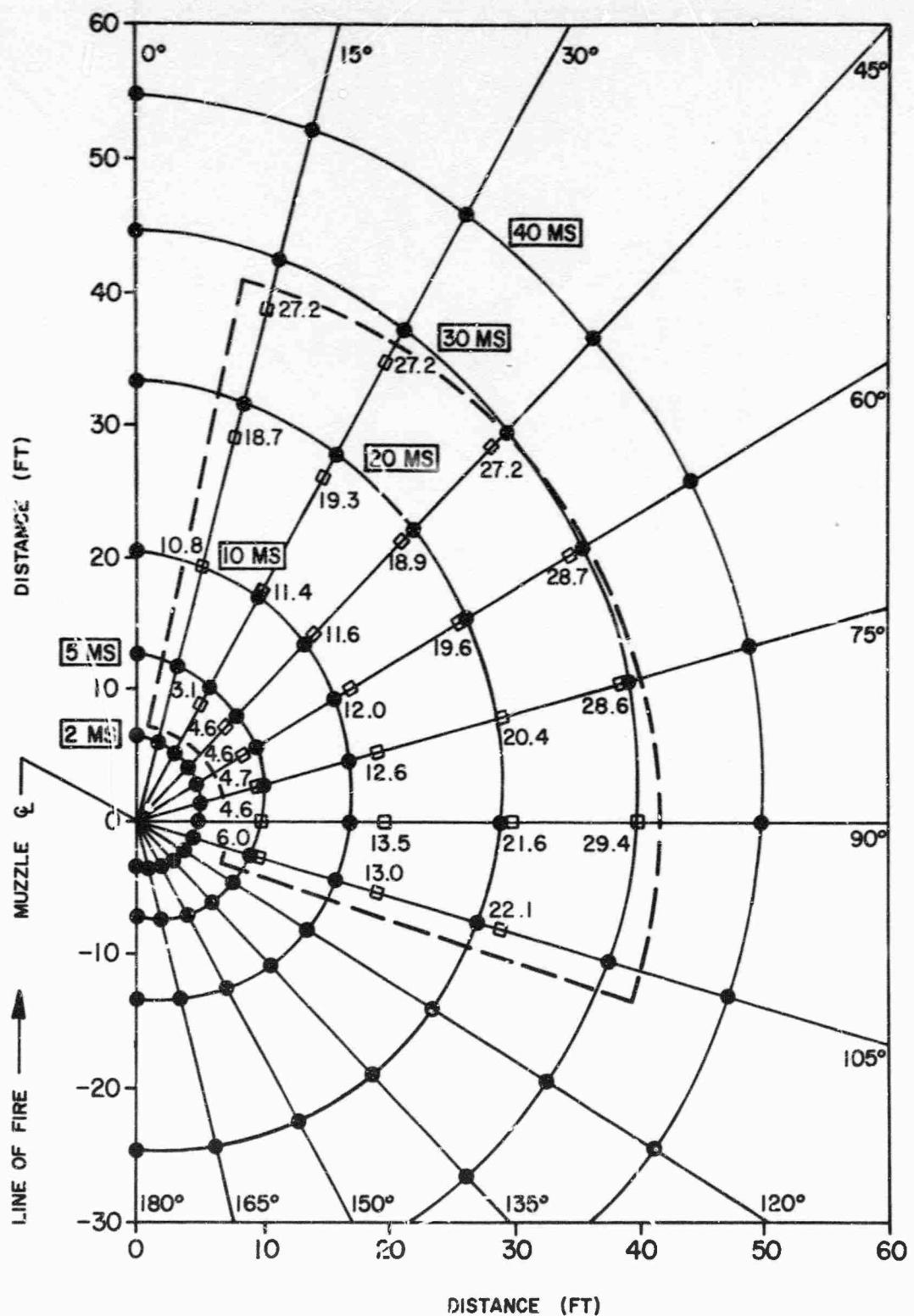
FREE-AIR PEAK PRESSURE CURVES FOR 6"/47 GUN

FIGURE A-6



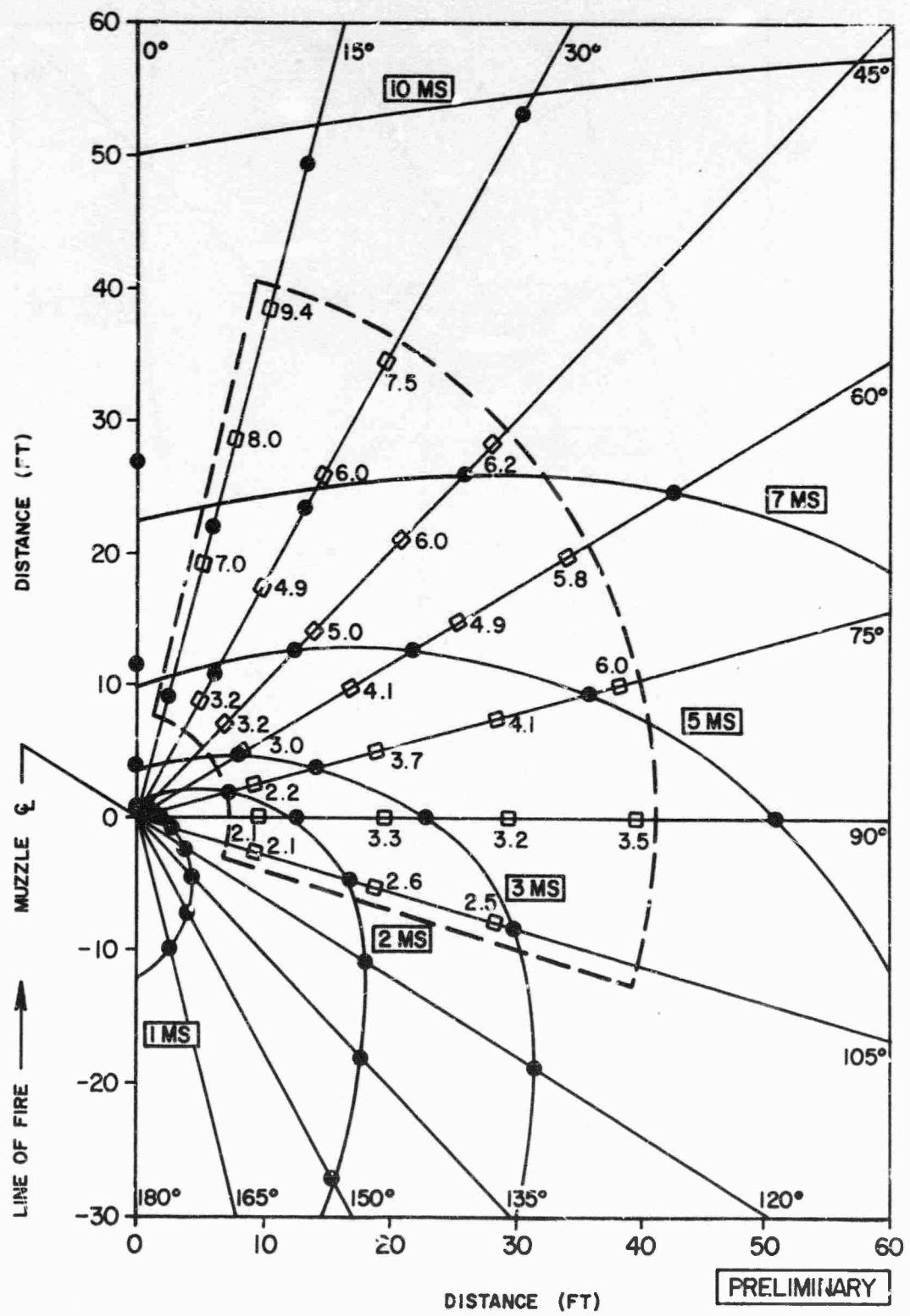
FREE-AIR PEAK PRESSURE CURVES FOR 5"/54 GUN

FIGURE A-7



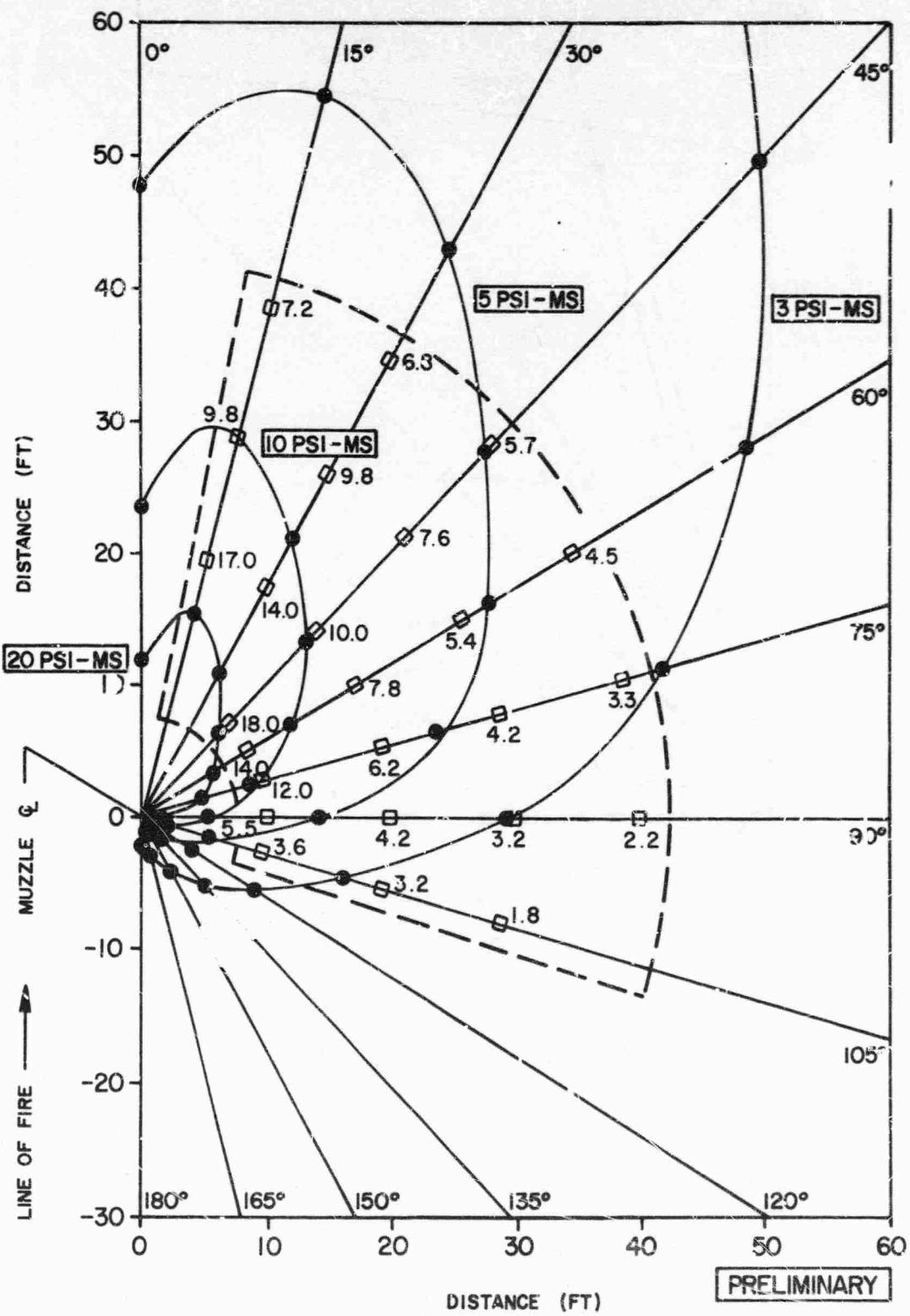
FREE-AIR ARRIVAL TIMES FOR 5" /54 GUN

FIGURE A - 8



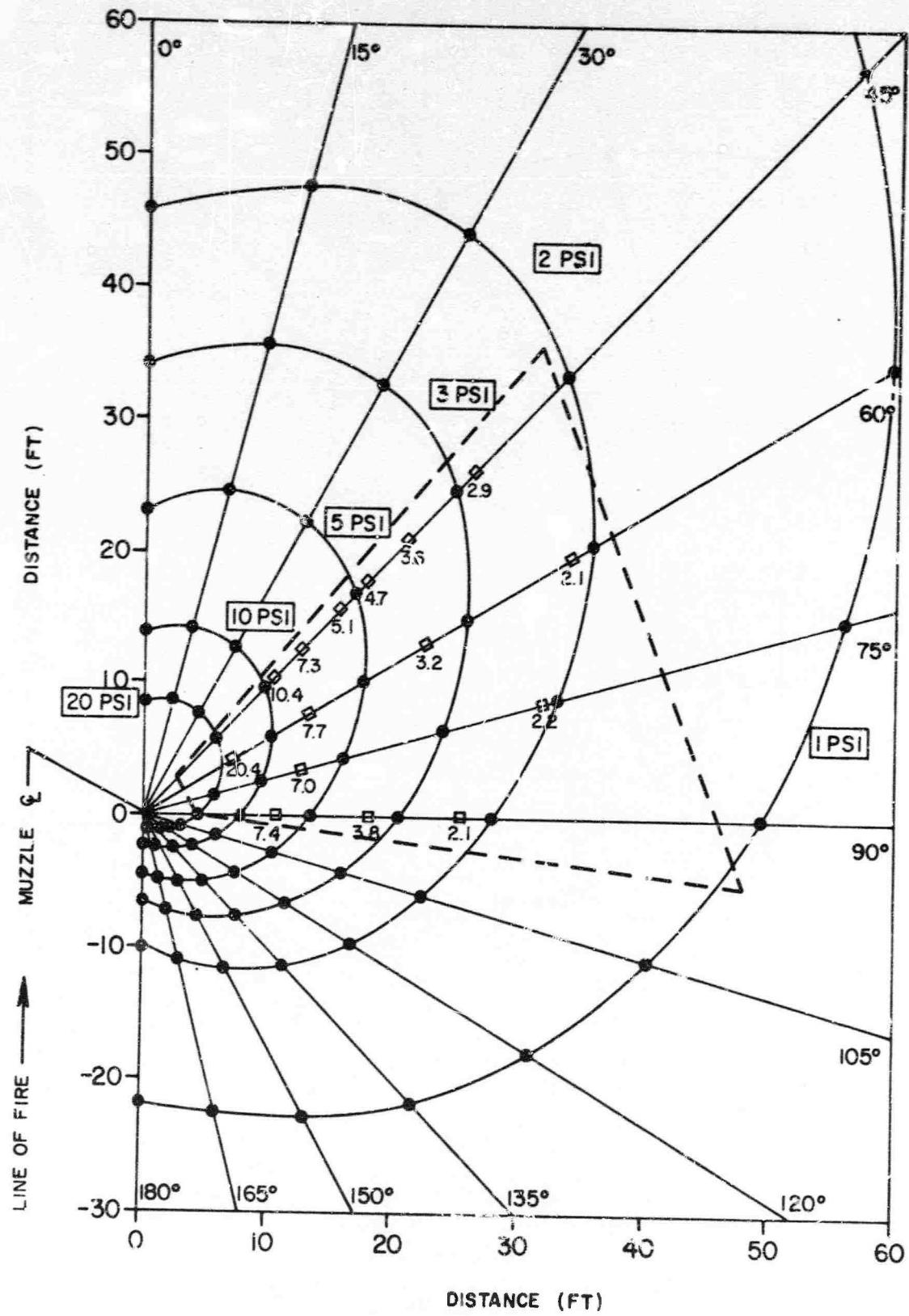
FREE-AIR DURATION FOR 5"/54 GUN

FIGURE A-9



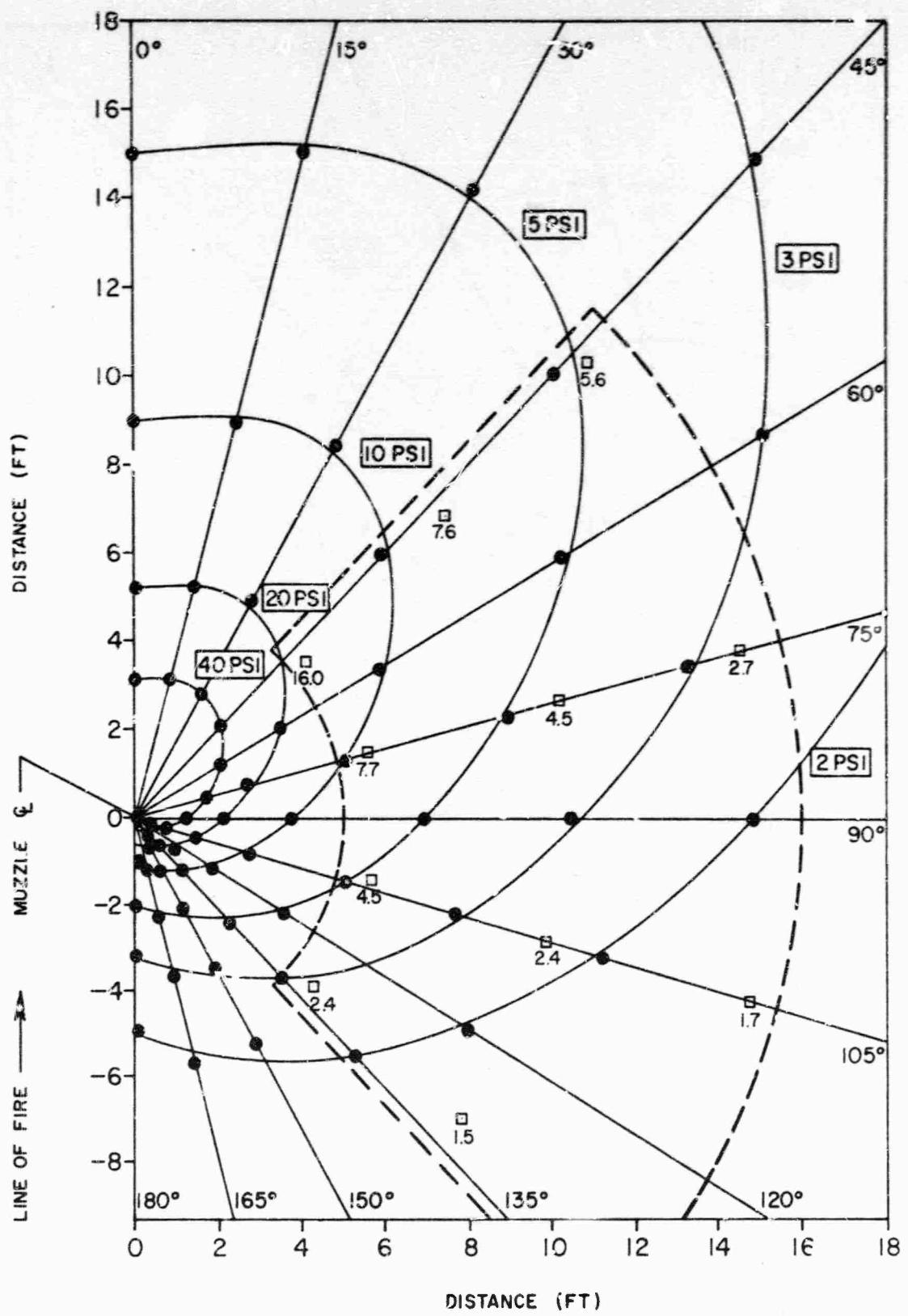
FREE-AIR IMPULSE FOR 5"/54 GUN

FIGURE A - 10



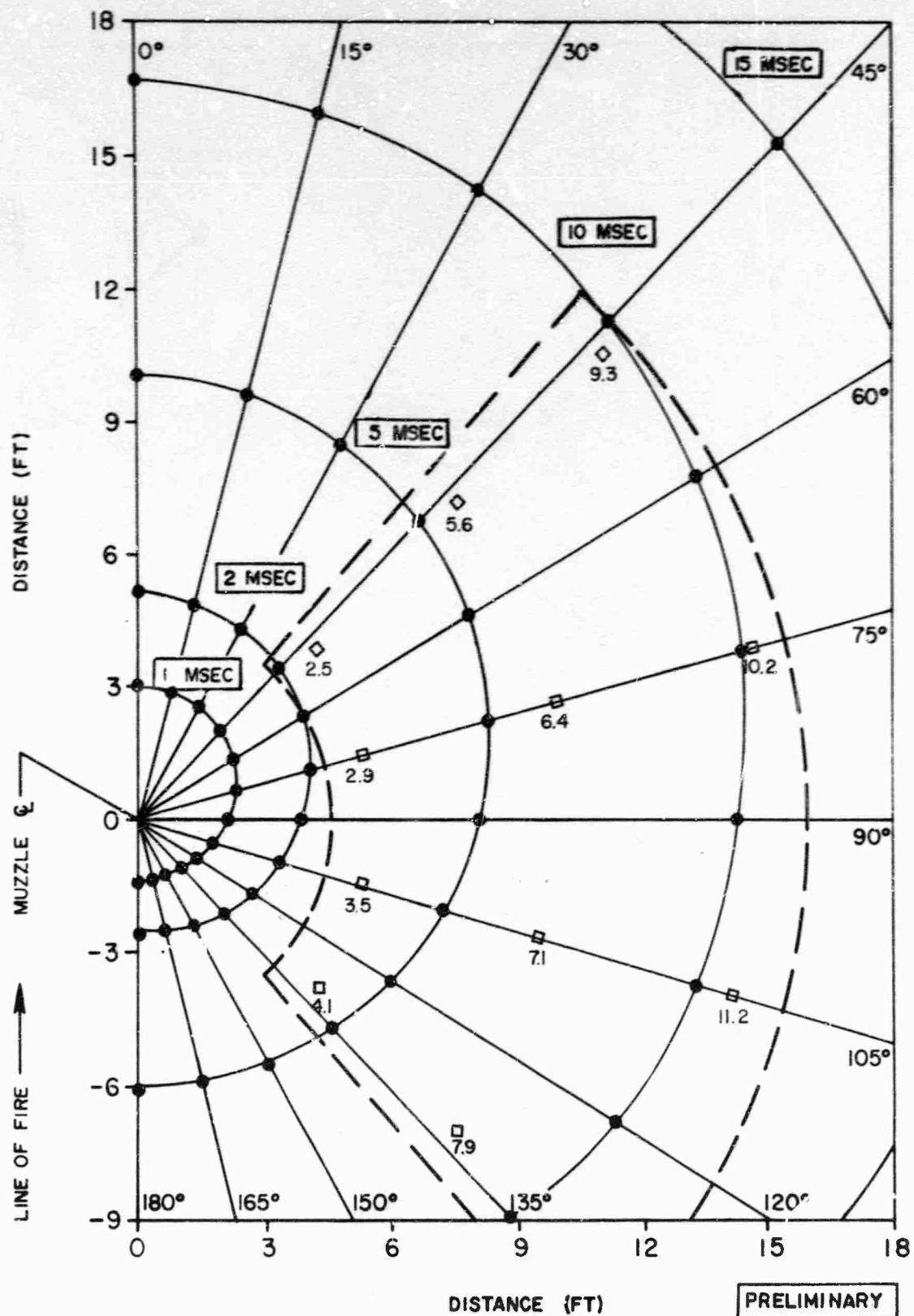
PREC-AIR PEAK PRESSURE CURVES FOR 5"/38 GUN

FIGURE A-II



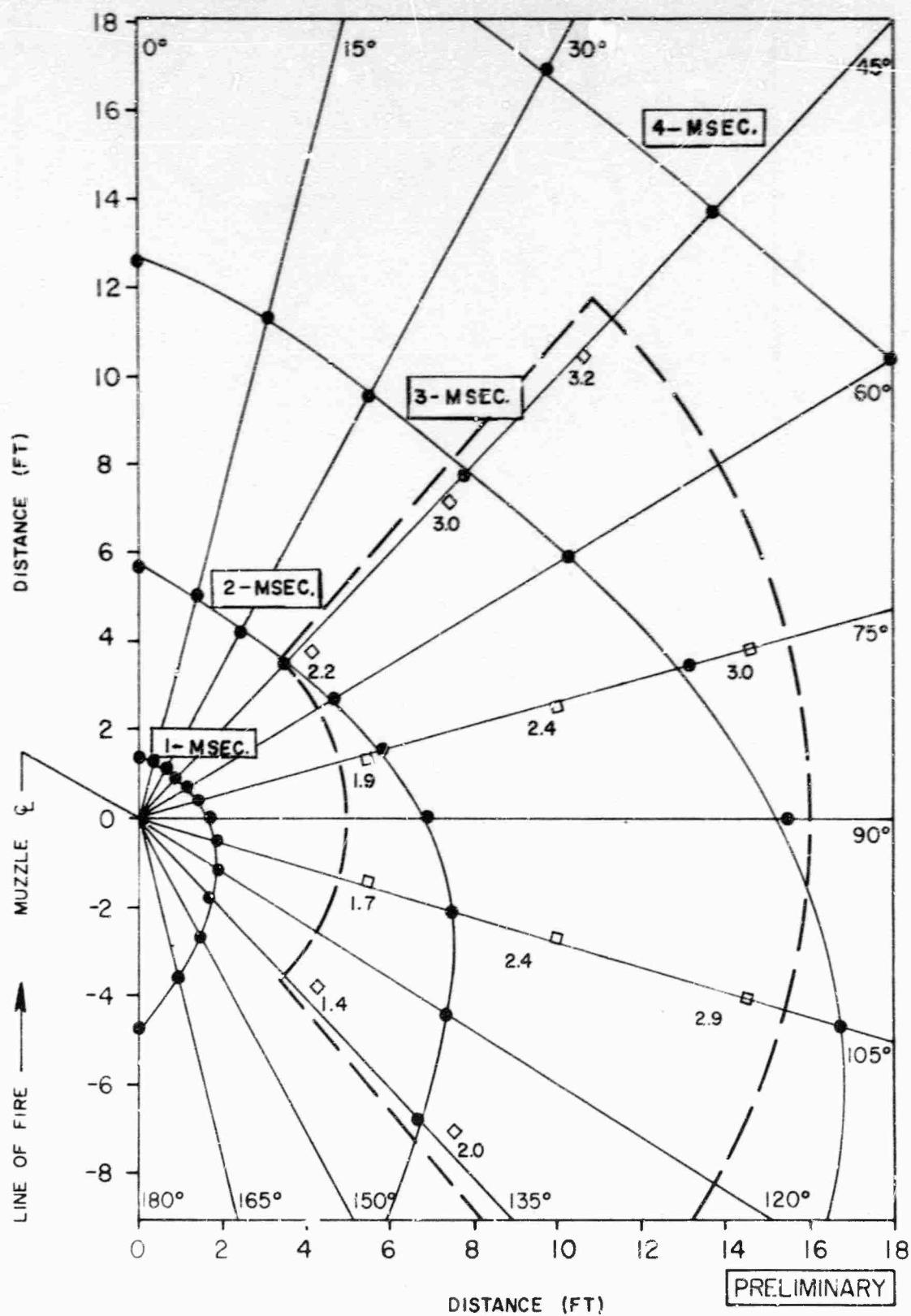
FREE-AIR PEAK PRESSURE CURVES FOR 3"/50 GUN

FIGURE A-12



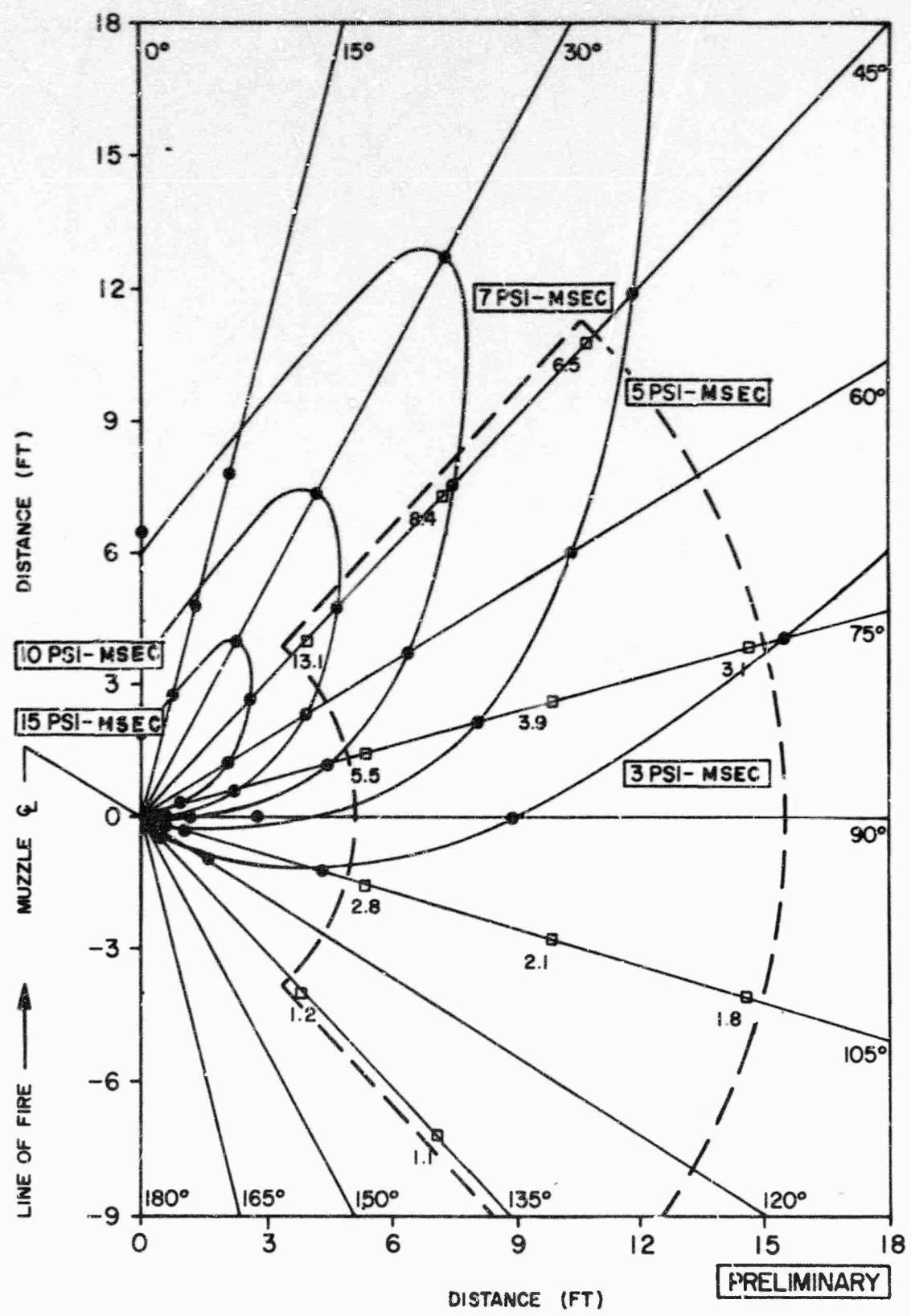
FREE-AIR ARRIVAL TIME CURVES FOR 3"/50 GUN

FIGURE A-13



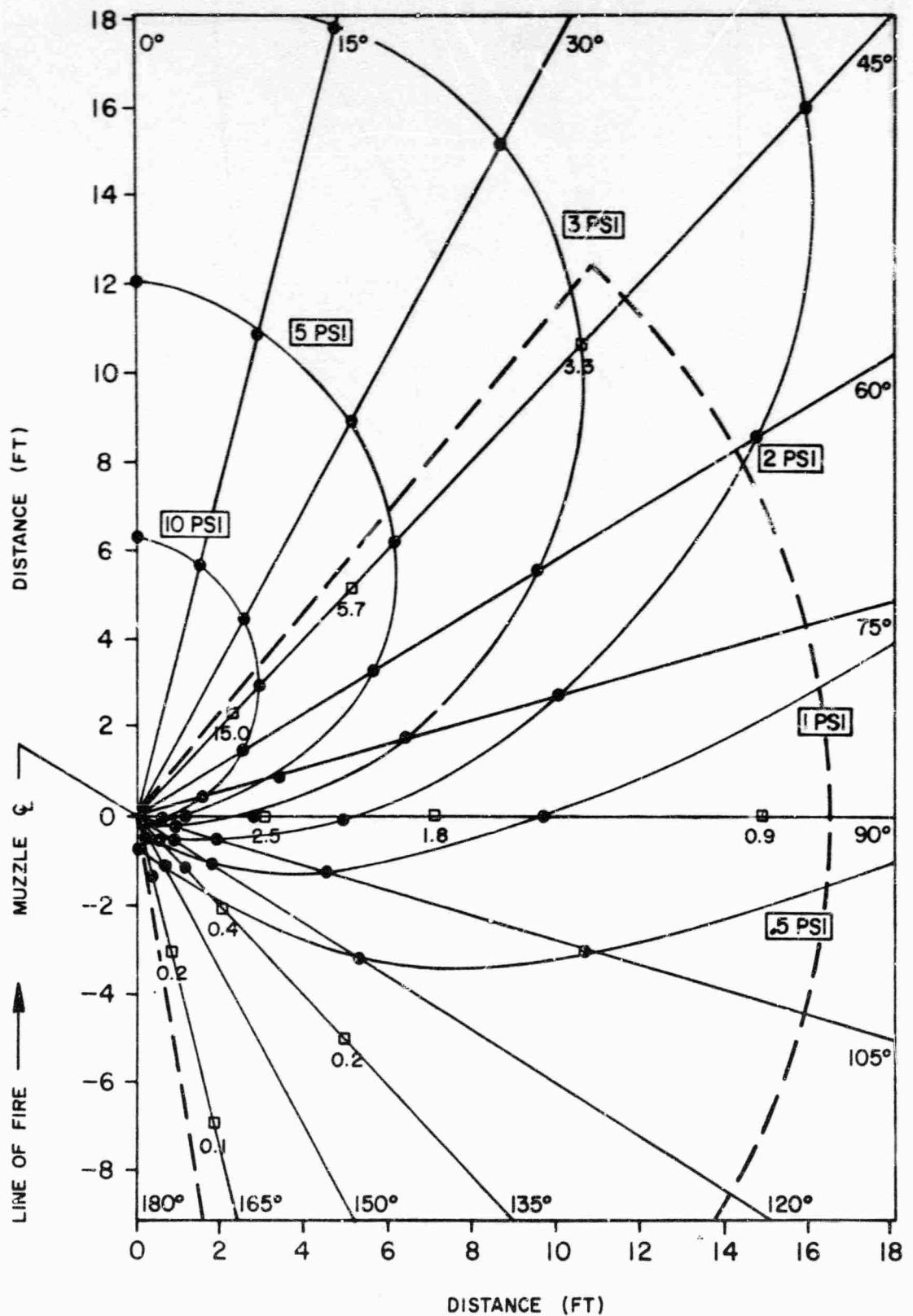
FREE-AIR DURATION CURVES FOR 3"/50 GUN

FIGURE A-14



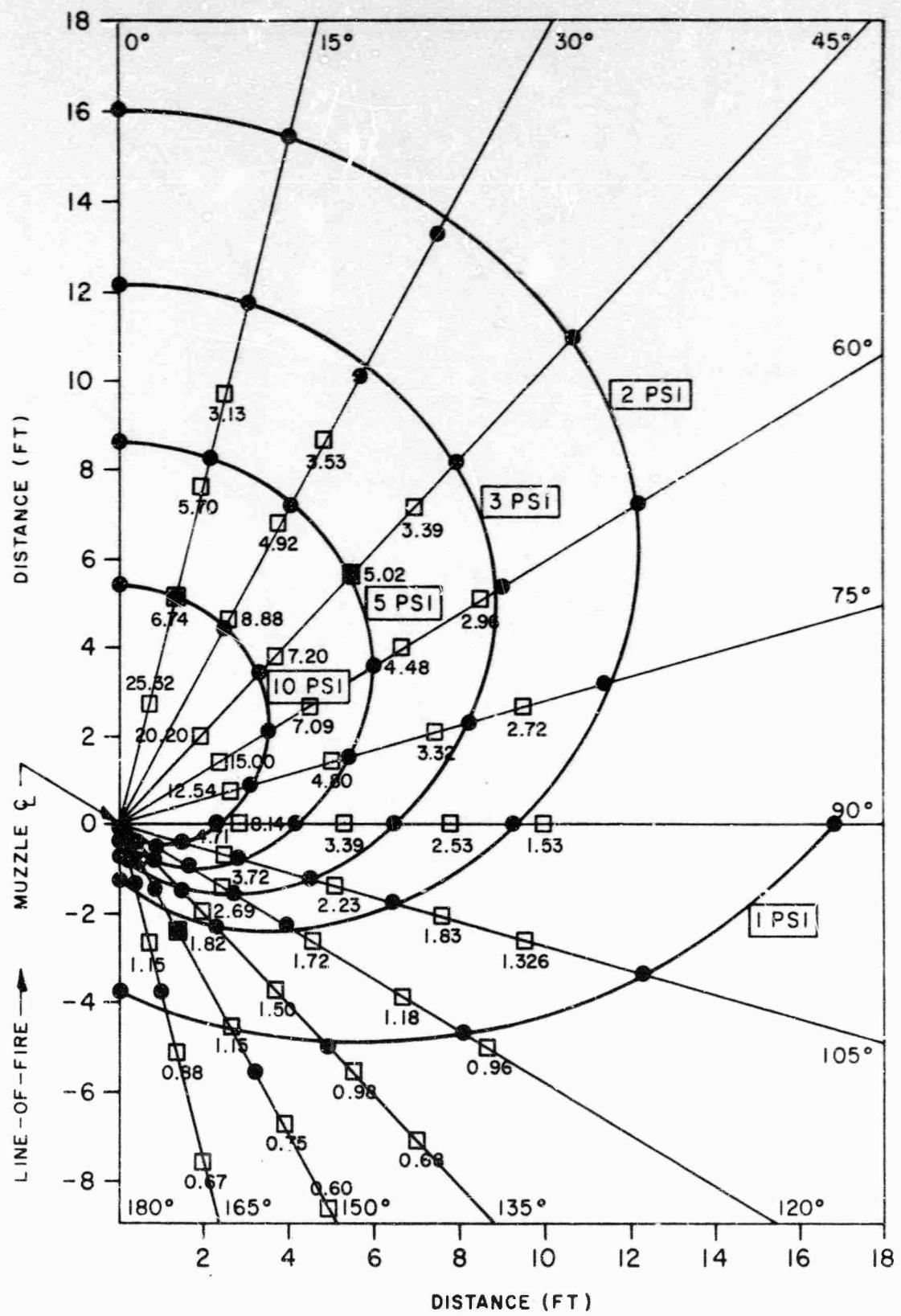
FREE-AIR IMPULSE CURVES FOR 3"/50 GUN

FIGURE A-15



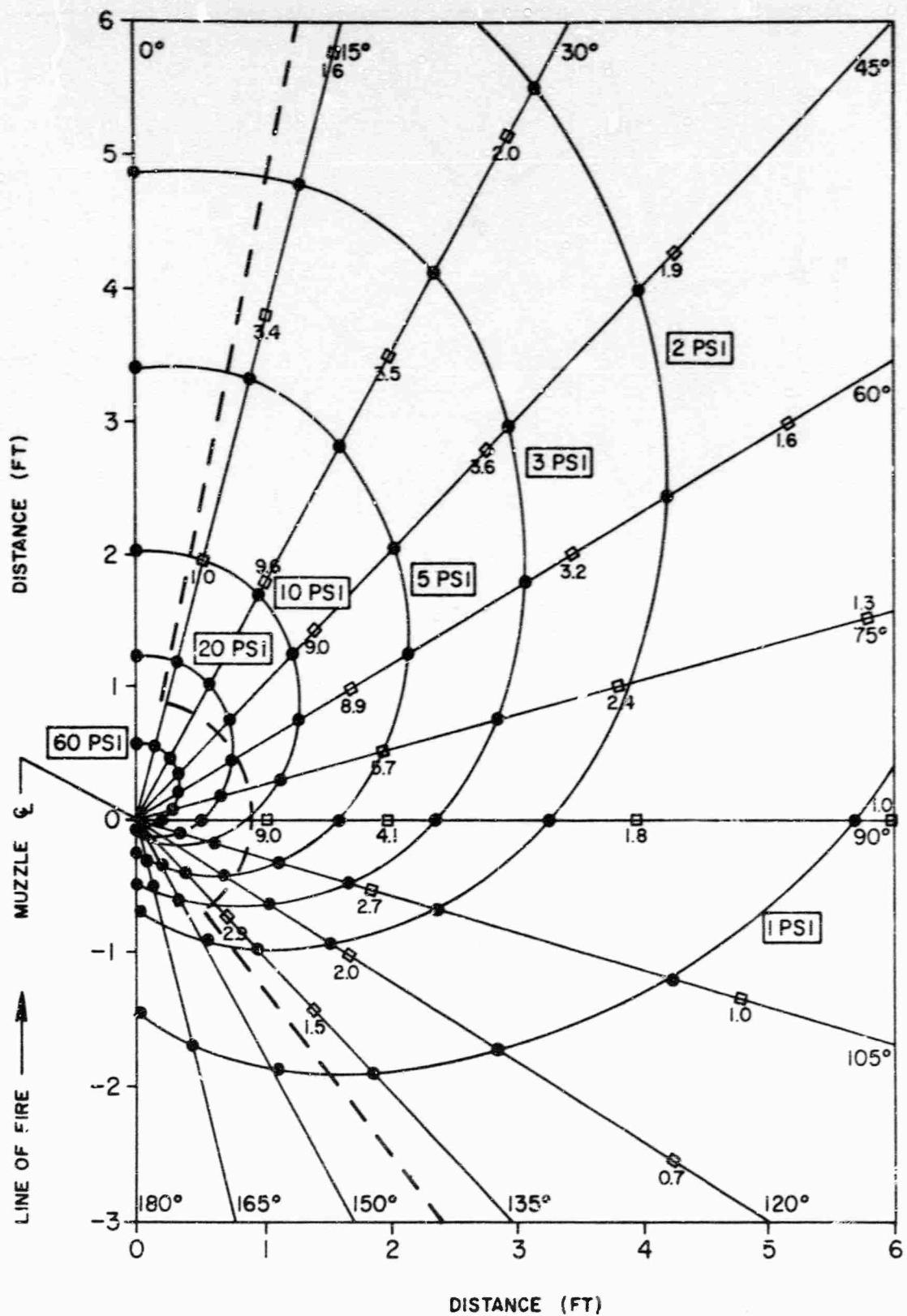
FREE-AIR PEAK PRESSURE CURVES FOR
40 MM GUN WITH FLASH HIDER

FIGURE A-16



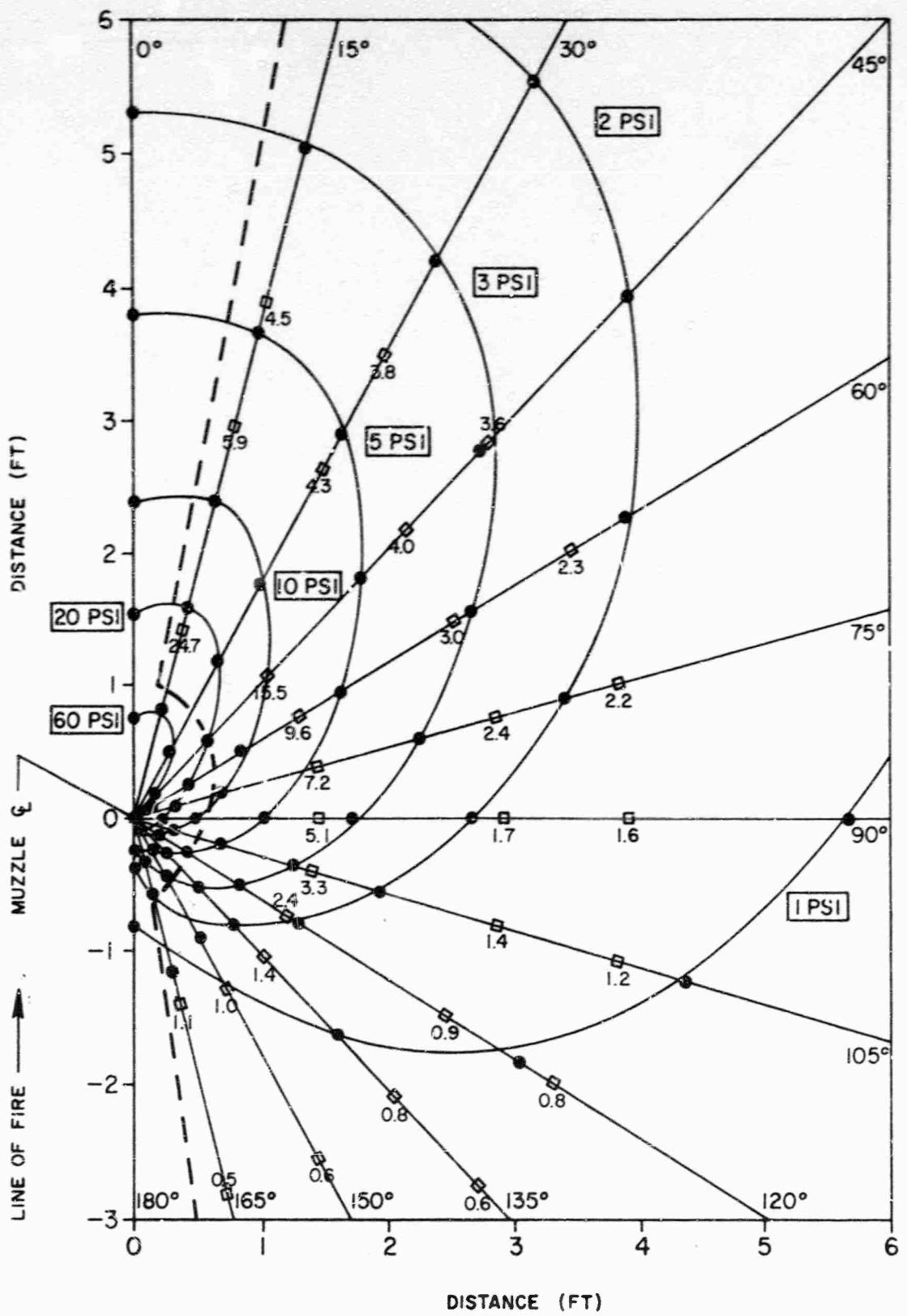
FREE-AIR PEAK PRESSURE CURVES FOR
40 MM GUN WITHOUT FLASH HIDER

FIGURE A-17



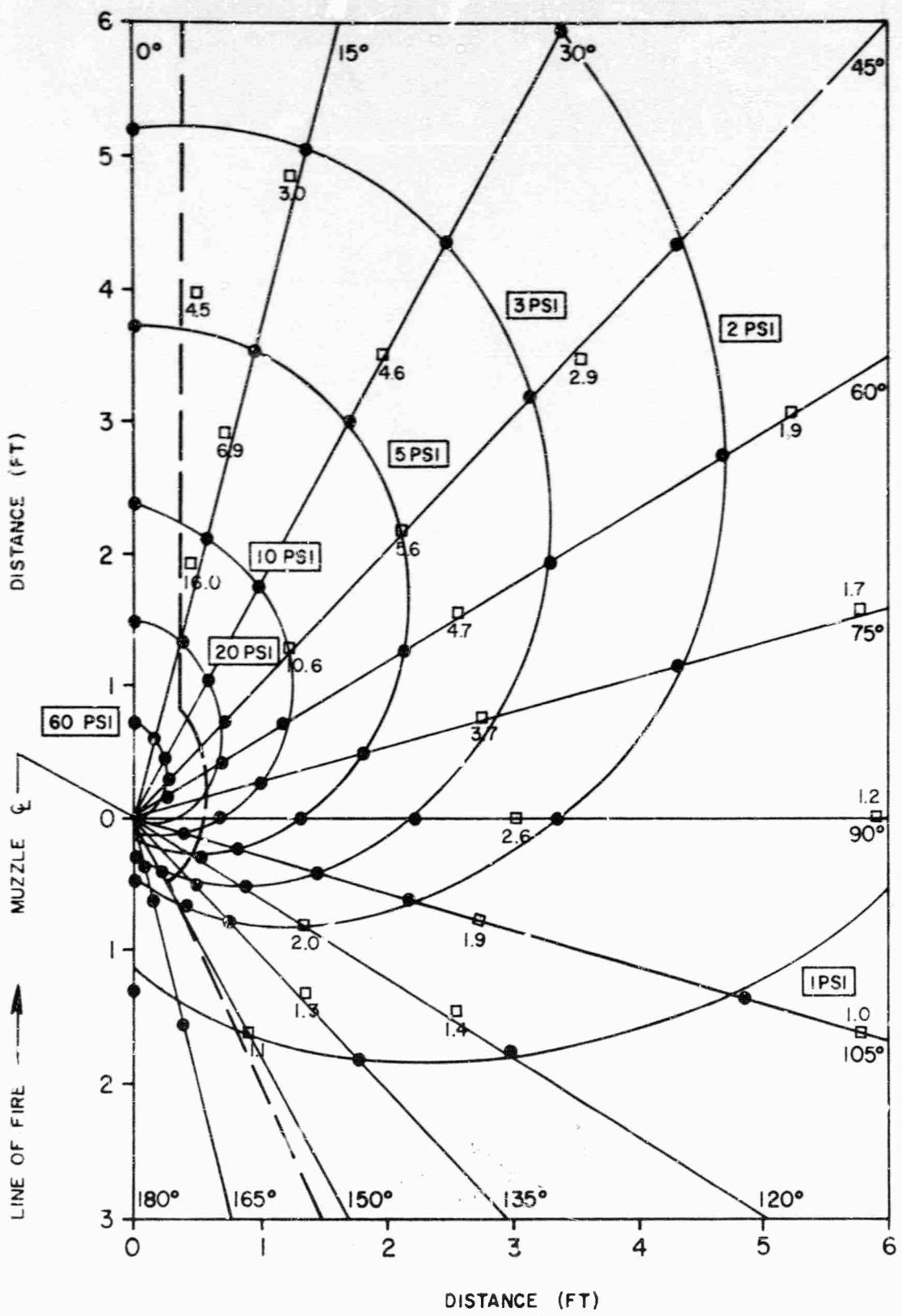
FREE-AIR PEAK PRESSURE CURVES FOR 20 MM M3 GUN

FIGURE A-18



FREE-AIR PEAK PRESSURE CURVES FOR 20 MM XM 197 GUN

FIGURE A-19



FREE-AIR PEAK PRESSURE CURVES FOR 20 MM MK 12 GUN

FIGURE A-20

APPENDIX B

CURVE FITTING COMPUTER PROGRAM LISTING

APPENDIX B

CURVE FITTING COMPUTER PROGRAM LISTINGS

- B-1 Listing of Program
- B-2 Listing of Subroutine
- B-3 Flow Chart of Program

LIST B-I LISTING OF PROGRAM

```

PROGRAM MAIN(INPUT,OUTPUT,TAPE5=INPUT,TAPES=OUTPUT)
DIMENSION X(13),Y(13),W(13),D(25),S(25)
DIMENSION A(9),B(9),C(13),F(13),PHIX(39)
DIMENSION D1(13),D2(13),U3(13),U10(13)
DIMENSION G(13),GN(13),XA(13),XN(13)
5   READ 950,A1,A2,A3,A4,A5,A6,A7
950 FORMAT(7A10)
PRINT 955,A1,A2,A3,A4,A5,A6,A7
955 FORMAT(1H1,//////////,6X,7A10)
10  KD=8
KN=17
DC 5 I=1,13
C(I)=0.
5 F(I)=0.
15  READ 10,(X(I),Y(I),W(I),I=1,13)
10 FORMAT(F5.0,F6.0,F10.0)
C
C      COMPUTE COEFFICIENTS FOR ORTHONORMAL POLYNOMIAL FIT OF Y
C
20  CALL RTHN (KD,KN,X,Y,A,PHIX,IERR)
IF(IERR)999,101,999
101 PRINT 994,A1,A2,A3,A4,A5,A6,A7
994 FORMAT(1H1,6X,7A10)
PRINT 850
25  850 FORMAT(1H0,/////,30X,22H3 PSI PRESSURE CONTOUR)
PRINT 103
103 FORMAT(//,14X,5HANGLE,11X,5HINPUT,12X,8HSMOOTHED)
PRINT 104
104 FORMAT(12X,9H(DEGREES),5X,13HDISTANCE (FT),5X,13HDISTANCE (FT),/)
30  C
C      COMPUTE FITTED VALUES OF Y, D2(K)
C
D0108 K=1,13
D2(K)=A(1)+A(2)*X(K)+A(3)*X(K)**2+A(4)*X(K)**3+A(5)*X(K)**4+
35  1A(6)**X(K)**5+A(7)*X(K)**6+B(8)*X(K)**7+B(9)*X(K)**8
PRINT 106,X(K),Y(K),D2(K)
106 FORMAT(13X,F6.2,10X,F7.2,11X,F7.2)
108 CONTINUE
C
40  C
C      COMPUTE COEFFICIENTS FOR ORTHONORMAL POLYNOMIAL FIT OF W
C
CALL RTHN (KD,KN,X,W,B,PHIX,IERR)
IF(IERR)999,107,999
107 PRINT 855
45  855 FORMAT(////////,30X,23H10 PSI PRESSURE CONTOUR)
PRINT 103
PRINT 104
C
C      COMPUTE FITTED VALUES OF W, D1(K)
C
D0 115 W=1,13
D1(K)=B(1)+B(2)*X(K)+B(3)*X(K)**2+B(4)*X(K)**3+B(5)*X(K)**4+
50  1B(6)*X(K)**5+B(7)*X(K)**6+B(8)*X(K)**7+B(9)*X(K)**8
PRINT 106,X(K),W(K),D1(K)
115 CONTINUE

```

```

C
C          COMPUTE COEFFICIENTS XA(K) AND EXPONENTS XN(K)
C          USING P=XA*D**XN
C
60      P1=10.
P2=3.
PRINT 994,A1,A2,A3,A4,A5,A6,A7
PRINT 121
121 FORMAT(1H0,////,15Y,1HW,10X,1HY-7X,1HX,12X,2HZN,12X,2HXA,/)

65      DO 127 K=1,13
XN(K)=(ALOG(P1)-ALOG(P2))/(ALOG(D1(K))-ALOG(D2(K)))
XA(K)=P1/(D1(K)**XN(K))
PRINT 122,D1(K),D2(K),X(K),XN(K),XA(K).
122 FORMAT  (11X,F8.4,3X,F8.4,3X,F5.1,3X,F11.5,3X,F11.5)
127 CONTINUE

C
C          COMPUTE COEFFICIENTS FOR ORTHONORMAL POLYNOMIAL FIT OF XN
C
75      CALL RTHN (KD,KN,X,XN,C,PHIX,IERR)
IF(IERR)999,125,999
125 PRINT 128
128 FORMAT(///,15X,1HX,14X,2HZN,17X,1HC,/)

DO 129 K=1,13
PRINT 126,X(K),XN(K),C(K)
126 FORMAT(13X,F5.1,4X,F12.5,4X,E20.12)
129 CONTINUE

C
C          COMPUTE COEFFICIENTS FOR ORTHONORMAL POLYNOMIAL FIT OF XA
C
85      CALL RTHN (KD,KN,X,XA,F,PHIX,IERR)
IF(IERR)999,401,999
401 PRINT 400
400 FORMAT(///,15X,1HX,14X,2HXA,17X,1HF,/)

DO 131 K=1,13
PRINT 126,X(K),XA(K),F(K)
131 CONTINUE

C
C          COMPUTE FITTED VALUES OF XN AND XA,
C          GN(K) AND GA(K) RESPECTIVELY
C
95      PRINT 994,A1,A2,A3,A4,A5,A6,A7
PRINT 151
151 FORMAT(1H0,////////,7X,2HGN,14X,2HGA,9X,1HX,10X,2H02,13Y,2HU3,/)

DO 155 K=1,13
GN(K)=C(1)+C(2)*X(K)+C(3)*X(K)**2+C(4)*X(K)**3+C(5)*X(K)**4+
1C(6)*X(K)**5+C(7)*X(K)**6+C(8)*X(K)**7+C(9)*X(K)**8
GA(K)=F(1)+F(2)*X(K)+F(3)*X(K)**2+F(4)*X(K)**3+F(5)*X(K)**4+
1F(6)*X(K)**5+F(7)*X(K)**6+F(8)*X(K)**7+F(9)*X(K)**8
U3(K)=GA(K)*D2(K)**GN(K)
PRINT 152,GN(K),GA(K),X(K),D2(K),U3(K)
152 FORMAT  (F12.5,5X,F12.5,5X,F5.1,5X,F9.5,5X,F9.5)
155 CONTINUE
PRINT 157
157 FORMAT(///,7X,2HGN,14X,2HGA,9X,1HX,10X,2H01,13X,3HU10,/)

DO 158 K=1,13

```

```

U10(K)=G8(K)*D1(K)**GN(K)
PRINT 152,GN(K),GA(K),X(K),D1(K),U10(K)
158 CONTINUF
C
C          COMPUTE D(KK) USING SPECIFIED S(KK) VALUES
C
115      PRINT 994,A1,A2,A3,A4,A5,A6,A7
           PRINT 159
159      FORMAT(1H0,////,14X,5HANGLE,9X,8HCINSTANCE,7X,5HPRESSURE)
120      PRINT 160
160      FORMAT(12X,9H(DEGREES),8X,6H(FEET),10X,5H(PSI),/)
           S(1)=2000.0
           S(2)=1000.0
           S(3)= 200.0
125      S(4)= 100.0
           S(5)= 60.0
           S(6)= 40.0
           S(7)= 30.0
           S(8)= 20.0
130      S(9)= 15.0
           S(10)= 10.0
           S(11)= 9.0
           S(12)= 8.0
           S(13)= 7.0
135      S(14)= 6.0
           S(15)= 5.0
           S(16)= 4.0
           S(17)= 3.0
           S(18)= 2.0
140      S(19)= 1.0
           S(20)= 0.5
           S(21)= 0.1
           DO 250 J=1,7
           DO 240 I=1,2
145      K=2*I+J-2
           IF(K-14)163,250,250
163      CONTINUE
           DO 165 KK=1,21
           D(KK)=(S(KK)/GA(K))** (1./GN(K))
150      165      PRINT 168,X(K),D(KK),S(KK)
           168      FORMAT(13X,F7.2,7X,F9.4,6X,F9.3)
           PRINT 169
           169      FORMAT(/)
           240      CONTINUE
155      PRINT 994,A1,A2,A3,A4,A5,A6,A7
           PRINT 159
           PRINT 160
           250      CONTINUF
C
C          COMPUTE FIRST AND SECOND MOMENTS FOR STATISTICAL COMPARISON
C          BETWEEN COMPUTED AND EXPERIMENTAL VALUES
C
160      T=0
           C12=0
165      M=1

```

```

        PRINT 994,A1,A2,A3,A4,A5,A6,A7
        PRINT 897
170      897 FORMAT(1H0,//////,8X,14HEXPER. DATA PT,25X,8HPRESSURE,4X,
           15HPRESSURE)
        PRINT 898
175      898 FORMAT(8X,14HIDENTIFICATION,4X,5HANGLE,4X,9HDISTANCE,2X,
           112HEXPERIMENTAL,3X,6HFITTED)
        PRINT 899
180      899 FORMAT(12X,6HNUMBER,6X,9H{DEGREES},3X,6H(FEET),7X,5H(PSI),
           16X,5H(PSI),/)
299      299 READ(5,300)L,G,F,P3
           TF(IFOF(5))510,305
305      305 CONTINUE
300      300 FORMAT(I5,1X,3(F6.2,1X))
           JM=100*M
           JN=JM/45
           GH1=C(1)+C(2)*Q**2+C(4)*Q**3+C(5)*Q**4+
           1C(6)*Q**5+C(7)*Q**6+C(8)*Q**7+C(9)*Q**8
           GA1=F(1)+F(2)*Q+F(3)*Q**2+F(4)*Q**3+F(5)*Q**4+
185      1F(6)*Q**5+F(7)*Q**6+F(8)*Q**7+F(9)*Q**8
           P=GA1*E**GN1
           C10=P-P3
           C11=C10/P
           C12=C12+C11
           C13=C12/M
           C1=ARS(C10)
           C2=C1/P
           C3=C2**2
           T=T+C3
           T5=T/M
           N0=M
           M=M+1
           T1=SORT(T5)
           IF(JN-100)470,500,410
200      410 IF(JN-200)470,500,420
           420 IF(JN-300)470,500,430
           430 IF(JN-400)470,500,440
           440 IF(JN-500)470,500,450
           450 IF(JN-600)470,500,451
           451 IF(JN-700)470,500,452
           452 IF(JN-800)470,500,453
           453 IF(JN-900)470,500,454
           454 IF(JN-1000)470,500,455
           455 IF(JN-1100)470,500,456
210      456 IF(JN-1200)470,500,457
           457 IF(JN-1300)470,500,460
           460 IF(JN-1400)470,500,510
500      500 PRINT 994,A1,A2,A3,A4,A5,A6,A7
           PRINT 897
           PRINT 898
           PRINT 899
470      470 PRINT 900,L,O,E,F3,P
900      900 FORMAT(12X,I5,8X,F6.2,3(4X,F8.3))
           GO TO 299
220      510 PRINT 901,C13

```

225

```
901 FORMAT(//,5X,14HFIRST MOMENT =,F8.2)
PRINT 902,T1
902 FORMAT(//,5X,15HSECOND MOMENT =,F7.2)
999 CONTINUE
END
```

LIST B-2 LISTING OF SUBROUTINE

```

      SUBROUTINE RTHN(KD,KN,X,Y,A,PHIX,IERR)
      DIMENSION X(100),Y(100),A(20),PHI(5,20),PHIX(3,100)

      C
      C          ERROR LIST
      C          IERR=5021 - DEGREE OF FIT GREATER THAN 19.
      C          IERR=5022 - DEGREE OF FIT EQUAL TO, OR GREATER
      C                      THAN, NUMBER OF POINTS.

      C          CONSISTENCY CHECK

      5          IF (KD>19) 2,2,1
      1          IERR=5021
      2          RETURN
      15         2 IF (KN>KD) 3,3,4
      3          IERR=5022
      4          RETURN
      4          4 IERR=0

      C          INITIALIZATION

      20         KDA=KD+1
      DO 7 K=1,KDA
      A(K)=0.0
      DO 7 J=1,5
      7          PHI(J,K)=0.0

      C          MAP ABSCISSAS ONTO THE CLOSED INTERVAL -1.0 TO +1.0
      C          USING Z=A+B*X

      25         CMAX=-1.0E+307
      CMIN=+1.0E+307
      DO 107 K=1,KN
      IF (XMAX-X(K)) 101,103,103
      101 XMAX=X(K)
      103 IF (XMIN-X(K)) 107,107,105
      105 XMIN=X(K)
      107 CONTINUE
      ZB=2.0/(XMAX-XMIN)
      ZA=-XMIN*ZB-1.0
      DO 12 K=1,KN
      12          PHIX(1,K)=ZA+ZB*X(K)

      C          COMPUTE FIRST ORTHONORMAL POLYNOMIAL
      C          AND DETERMINE ITS COEFFICIENT

      45         PHI(1,1)=1.0/SQRT (FLOAT (KN))
      C=0.0
      ALP=0.0
      DUMA=PHI(1,1)**2
      DO 21 K=1,KN
      ALP=ALP+PHIX(1,K)*DUMA
      21 C=C+PHI(1,1)*Y(K)
      PHI(4,1)=PHI(1,1)*C

      C          COMPUTE SECOND ORTHONORMAL POLYNOMIAL

```

```

      AND DETERMINE ITS COEFFICIENT
      C
      C
      C
      50   PHI(2,1)=-ALP*PHI(1,1)
            PHI(2,2)=PHI(1,1)
            ALAM=0.0
            DO 25 K=1,KN
            PHIX(2,K)=PHI(2,1)+PHI(2,2)*PHIX(1,K)
            25  ALAM=ALAM+PHIX(2,K)**2
            ALAM=SQRT (ALAM)
            PHI(2,1)=PHI(2,1)/ALAM
            PHI(2,2)=PHI(2,2)/ALAM
            C=0.0
            DO 27 K=1,KN
            PHIX(2,K)=PHIX(2,K)/ALAM
            27  C=C+PHIX(2,K)*(Y(K)-PHI(4,1))
            PHI(4,1)=PHI(4,1)+PHI(2,1)*C
            PHI(4,2)=PHI(2,2)*C
            C
            C          COMPUTE RESIDUALS
            C
            DO 28 K=1,KN
            28  PHIX(3,K)=Y(K)-PHI(4,1)-PHI(4,2)*PHIX(1,K)
            C
            C          ARE POLYNOMIALS HIGHER THAN FIRST
            C          DEGREE REQUIRED. NO,NO,YES
            C
            IF(KD-1)81,81,31
            C
            C          COMPUTE HIGHER DEGREE ORTHONORMAL POLYNOMIALS
            C          AND DETERMINE THEIR COEFFICIENTS
            C
            31  LA=1
            LR=2
            LC=3
            DO 79 KT=2,KD
            KTA=KT+1
            C
            C          COMPUTE ALPHA(T)
            C
            ALD=0.0
            DO 32 K=1,KN
            32  ALP=ALP+PHIX(1,K)*PHIX(2,K)**2
            C
            C          COMPUTE LAMBDA(T+1)*PHI(T+1)
            C
            PHI(LC,1)=0.0
            DO 33 K=1,KT
            PHI(LC,K)=PHI(LC,K)-ALP*PHT(LR,K)-ALAM*PHI(LR,K)
            33  PHI(LC,K+1)=PHI(LR,K)
            C
            C          COMPUTE LAMBDA(T+1)*PHT(T+1) OF Z
            C
            DO 34 I=1,KN
            PHIX(2,I)=PHI(LC,KTA)
            RTH 550
            RTH 550
            RTH 570
            RTH 580
            RTH 590
            RTH 600
            RTH 610
            RTH 620
            RTH 630
            RTH 640
            RTH 650
            RTH 660
            RTH 670
            RTH 680
            RTH 690
            RTH 700
            RTH 710
            RTH 720
            RTH 730
            RTH 740
            RTH 750
            RTH 760
            RTH 770
            RTH 780
            RTH 790
            RTH 800
            RTH 810
            RTH 820
            RTH 830
            RTH 840
            RTH 850
            RTH 860
            RTH 870
            RTH 880
            RTH 890
            RTH 900
            RTH 910
            RTH 920
            RTH 930
            RTH 940
            RTH 950
            RTH 960
            RTH 970
            RTH 980
            RTH 990
            RTH 1000
            RTH 1010
            RTH 1020
            RTH 1030
            RTH 1040
            RTH 1050
            RTH 1060
            RTH 1070
            RTH 1080
            RTH 1090
            RTH 1100

```

```

      DO 34 JA=1,KT          RTH 119
      JB=KTA-JA              RTH 111
      34 PHIX(2,I)=PHIX(2,I)*PHIX(1,I)+PHI(LC,JB)   RTH 120
      C                         RTH 1130
      C     COMPUTE LANDR(T+1)    RTH 1140
      C
      C     ALAM=0.0             RTH 1150
      DO 35 K=1,KN             RTH 1170
      35 ALAM=ALAM+PHIX(2,K)**2   RTH 1180
      ALAM=SQRT (ALAM)         RTH 1190
      C                         RTH 1200
      C     COMPUTE PHI(T+1) OF Z   RTH 1210
      C
      DO 36 K=1,KN             RTH 1220
      36 PHIX(2,K)=PHIX(2,K)/ALAM   RTH 1230
      C                         RTH 1240
      C     COMPUTE PHI(T+1)       RTH 1250
      C
      DO 37 K=1,KTA            RTH 1260
      37 PHI(LC,K)=PHI(LC,K)/ALAM   RTH 1270
      C                         RTH 1280
      C     COMPUTE COEFFICIENT OF ORTHONORMAL POLYNOMIAL  RTH 1290
      C
      C=C0.0                   RTH 1300
      DO 41 K=1,KN             RTH 1310
      41 C=C+PHIX(2,K)*PHIX(3,K)   RTH 1320
      C                         RTH 1330
      C     ACCUMULATE CONTRIBUTION OF THIS POLYNOMIAL      RTH 1340
      C     IN THE FORM OF POWERS OF Z                      RTH 1350
      C
      DO 42 K=1,KTA            RTH 1360
      42 PHI(4,K)=PHI(4,K)+PHI(LC,K)*C   RTH 1370
      C                         RTH 1380
      C     COMPUTE RESIDUALS           RTH 1390
      C
      DO 52 J=1,KN             RTH 1400
      PHTX(3,J)=PHI(4,KTA)        RTH 1410
      DO 51 K=1,KT              RTH 1420
      KTA=KTA-K                RTH 1430
      51 PHIX(3,J)=PHIX(3,J)*PHIX(1,J)+PHI(4,KTB)   RTH 1440
      52 PHTX(3,J)=Y(J)-PHTX(3,J)        RTH 1450
      C                         RTH 1460
      C     SHIFT VECTORS FOR THE NEXT RECURSION           RTH 1470
      C
      LS=LA                   RTH 1480
      LA=LB                   RTH 1490
      LB=LC                   RTH 1500
      LC=LS                   RTH 1510
      79 CONTINUE               RTH 1520
      C                         RTH 1530
      C     TRANSFORM COEFFICIENTS FROM Z TO X             RTH 1540
      C
      81 PHI(5,1)=ZA           RTH 1550
      PHI(5,2)=ZB             RTH 1560
      A(1)=PHI(4,1)+Z1*PHI(4,2)   RTH 1570
      RTH 1580
      RTH 1590
      RTH 1600
      RTH 1610
      RTH 1620
      RTH 1630
      RTH 1640

```

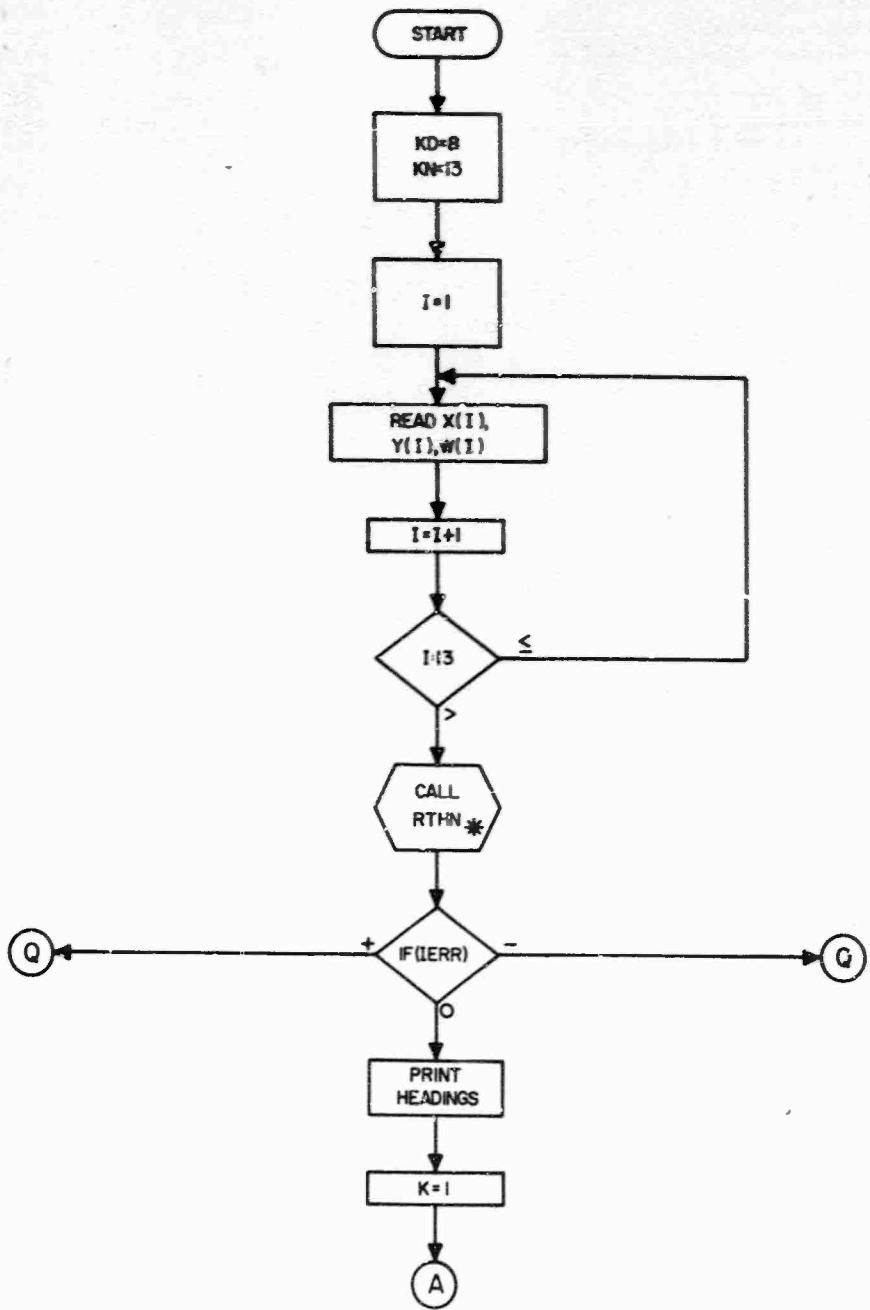
```

A(2)=ZB*PHI(4,2)
KDXQ=2
IF(KD=2 .I. 111,111,109
170   109 KDXQ=KD
      111 DO 87 K=2,KDXQ
           KB=K+1
           ZZ=0.0
           DO 83 KA=1,K
           ZY=PHI(5,KA)*ZB
           PHI(5,KA)=PHI(5,KA)+ZA+ZZ
           83 ZZ=ZY
           PHI(5,KB)=ZZ
           DO 85 KA=1,KB
           85 A(KA)=A(KA)+PHI(4,KB)*PHI(5,KA)
           87 CONTINUE
           99 RETURN
           END

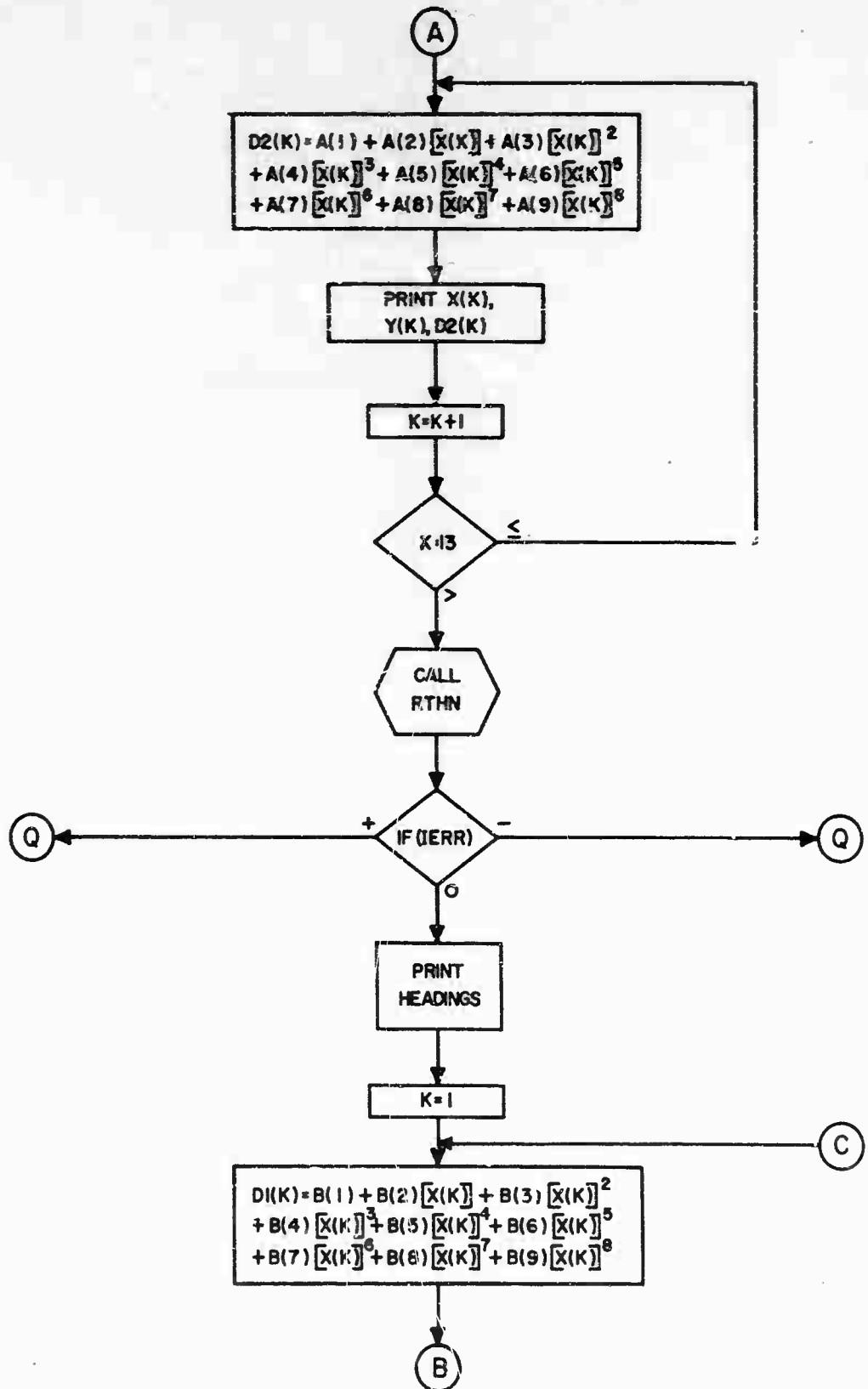
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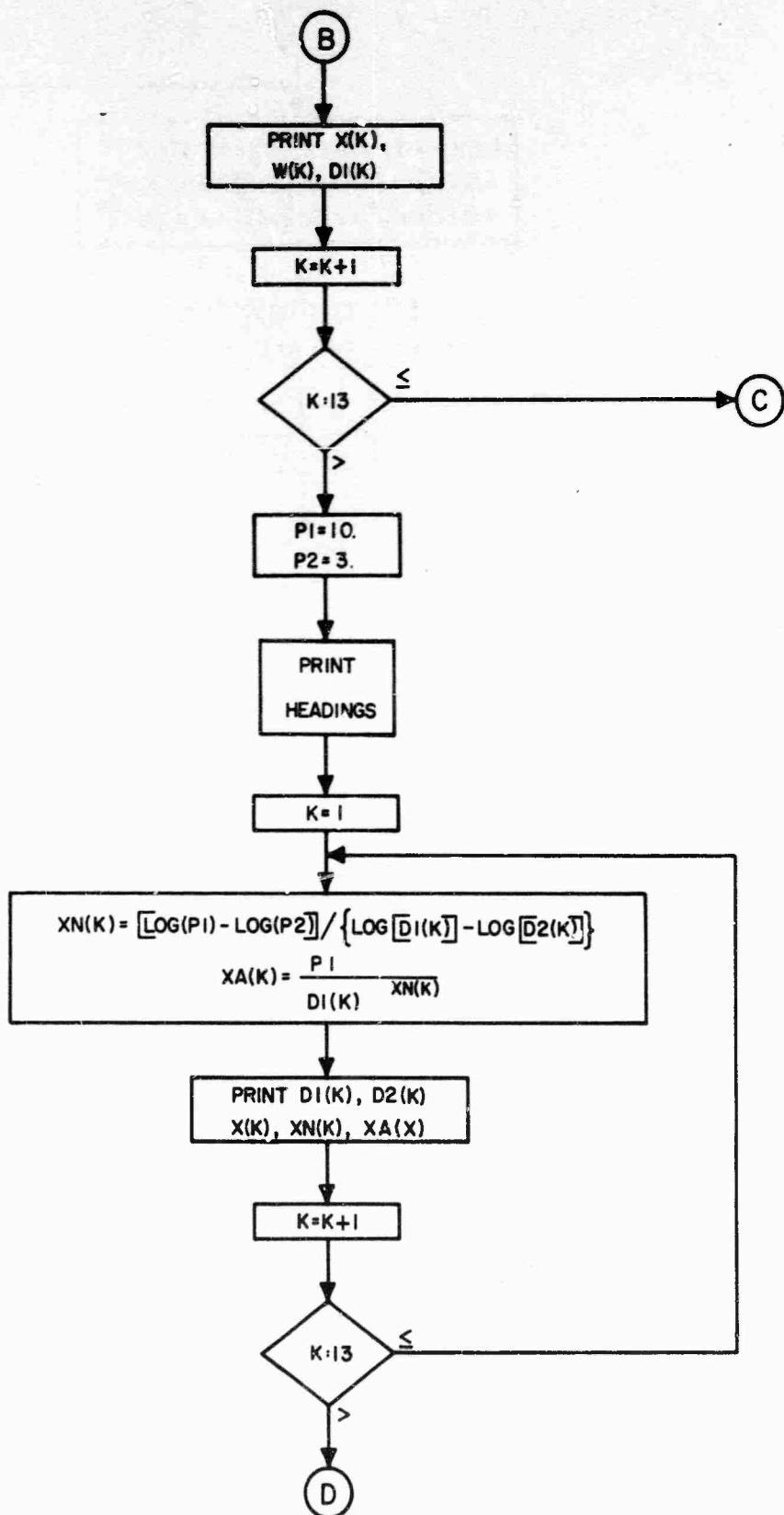
RTH 1650
RTH 1660
RTH 1670
RTH 1680
RTH 1690
RTH 1700
RTH 1710
RTH 1720
RTH 1730
RTH 1740
RTH 1750
RTH 1760
RTH 1770
RTH 1780
RTH 1790
RTH 1800
RTH 1810

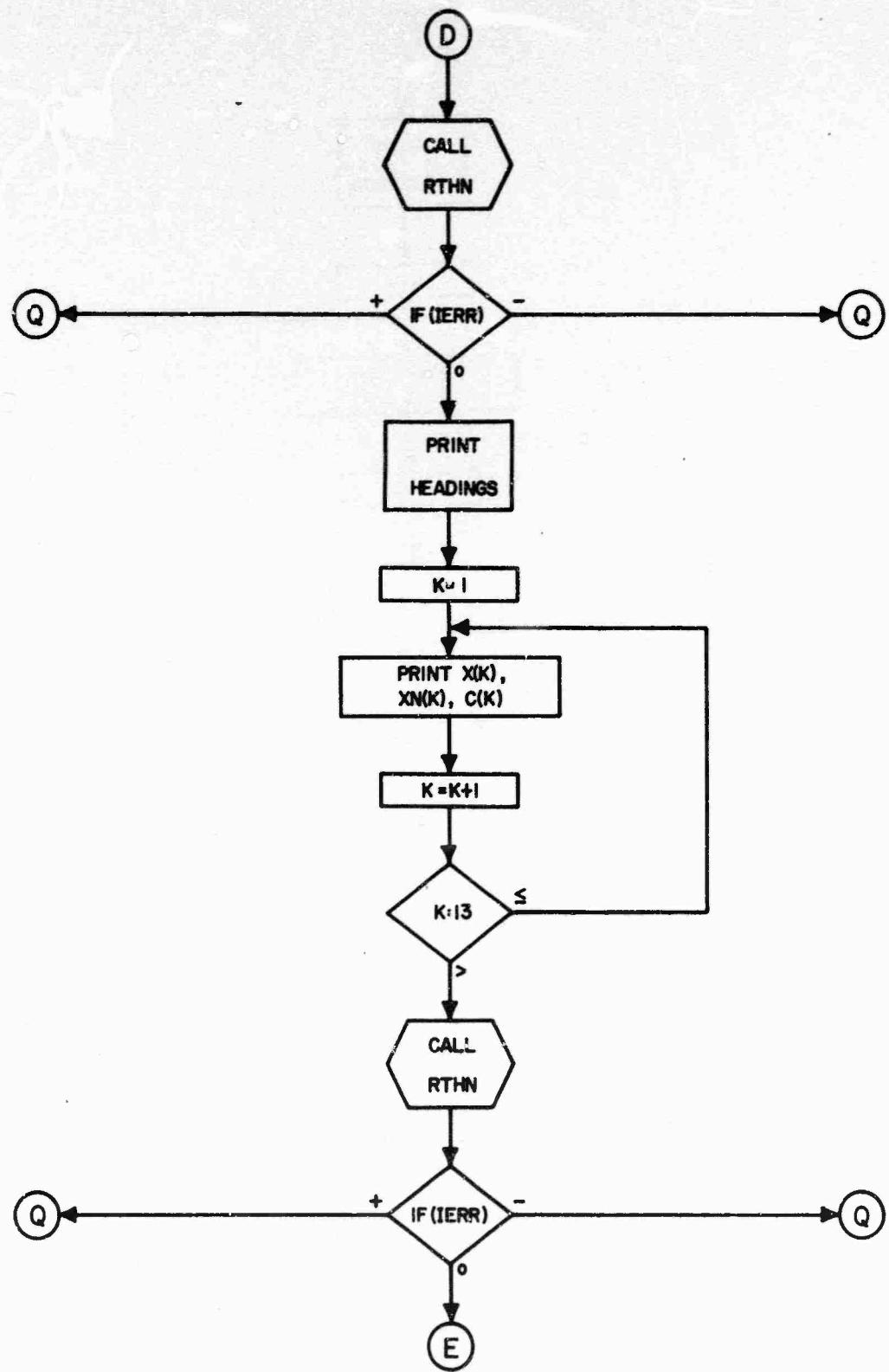
CHART B-3 FLOW CHART OF PROGRAM

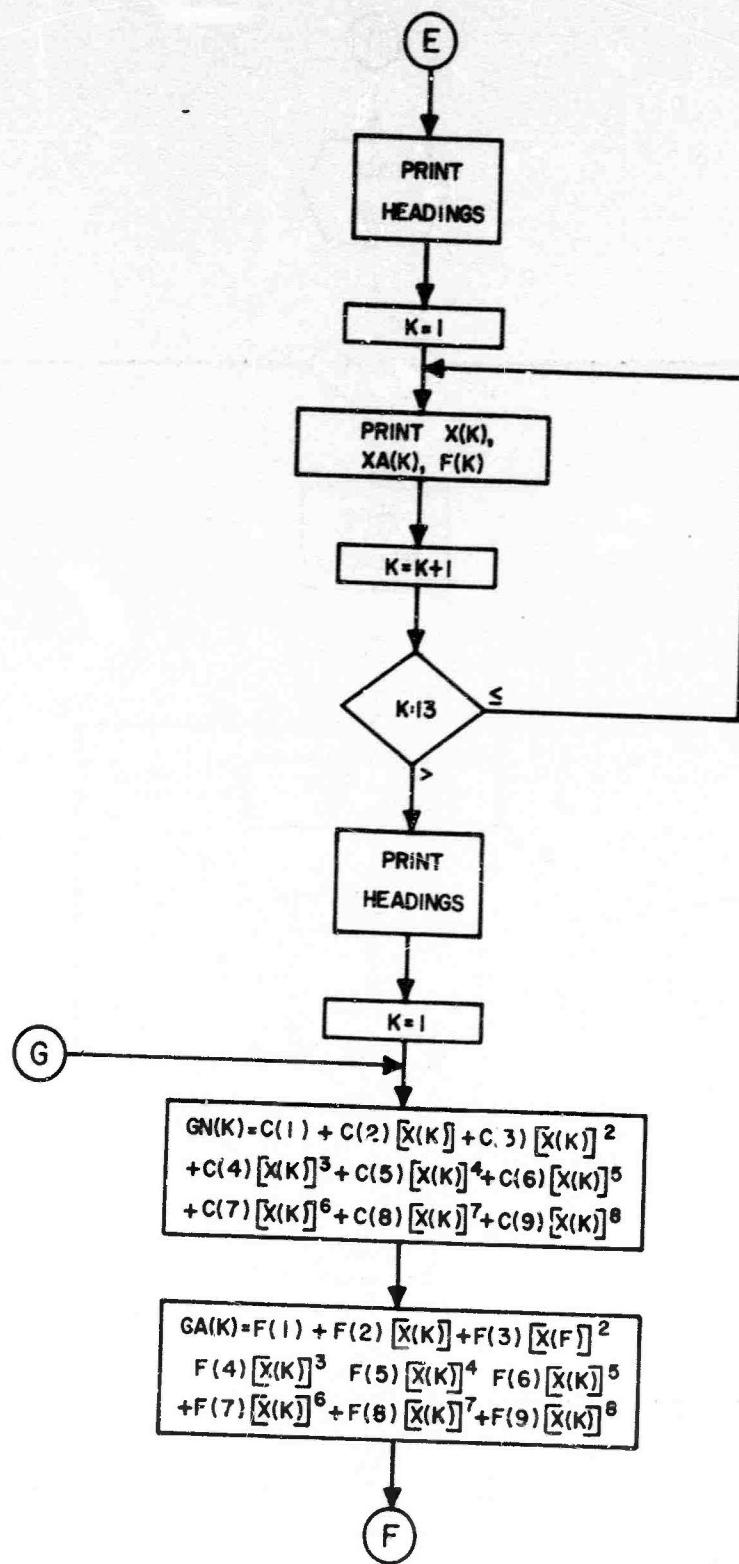


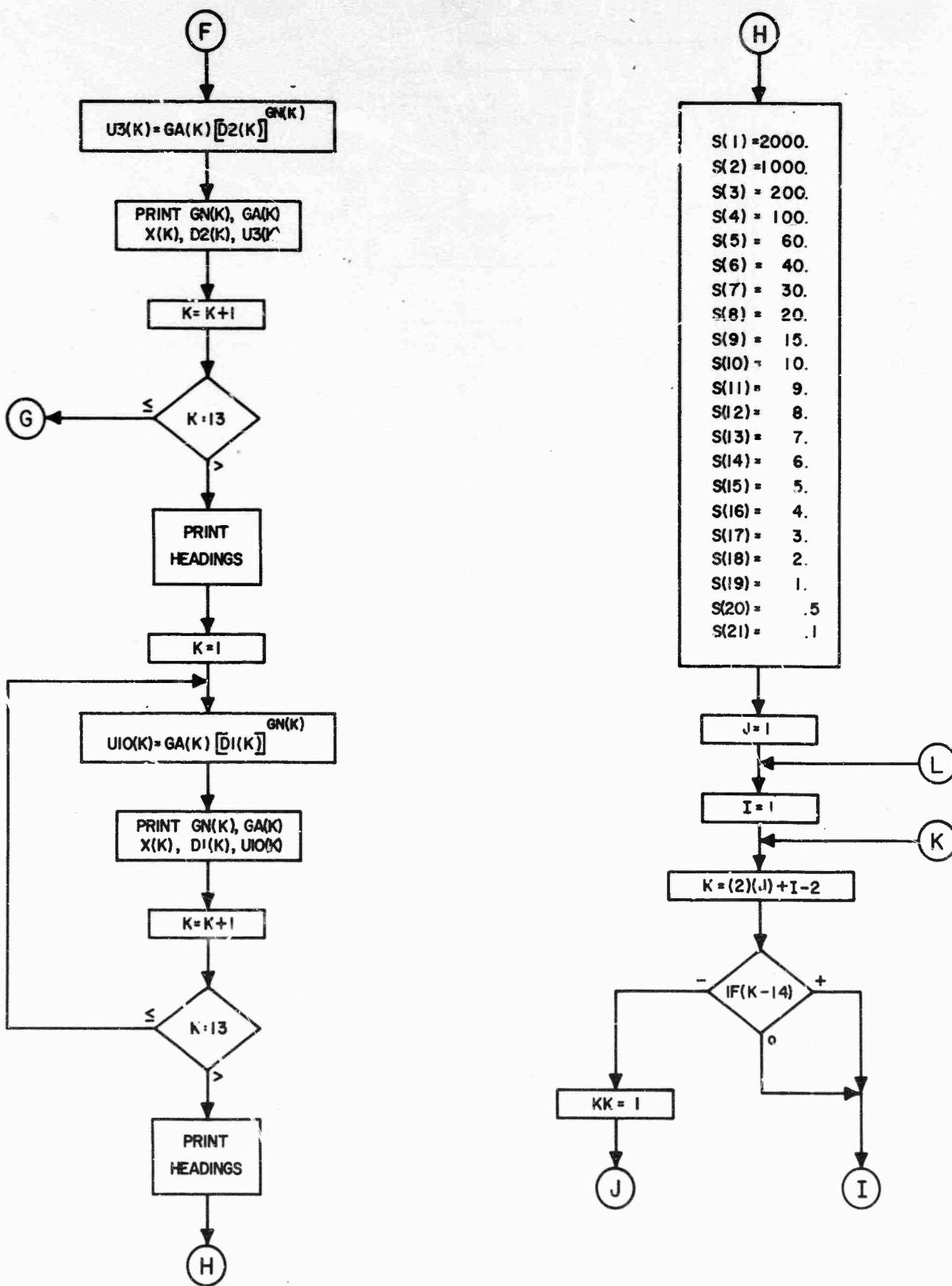
FORSYTHE, G.E. (1957) "GENERATION AND USE OF CIRCUMPOLYNOMIALS FOR DATA FITTING WITH A DIGITAL COMPUTER," J. SOC. FOR INDUST. AND APPL. MATH., VOL. 5, P 74.

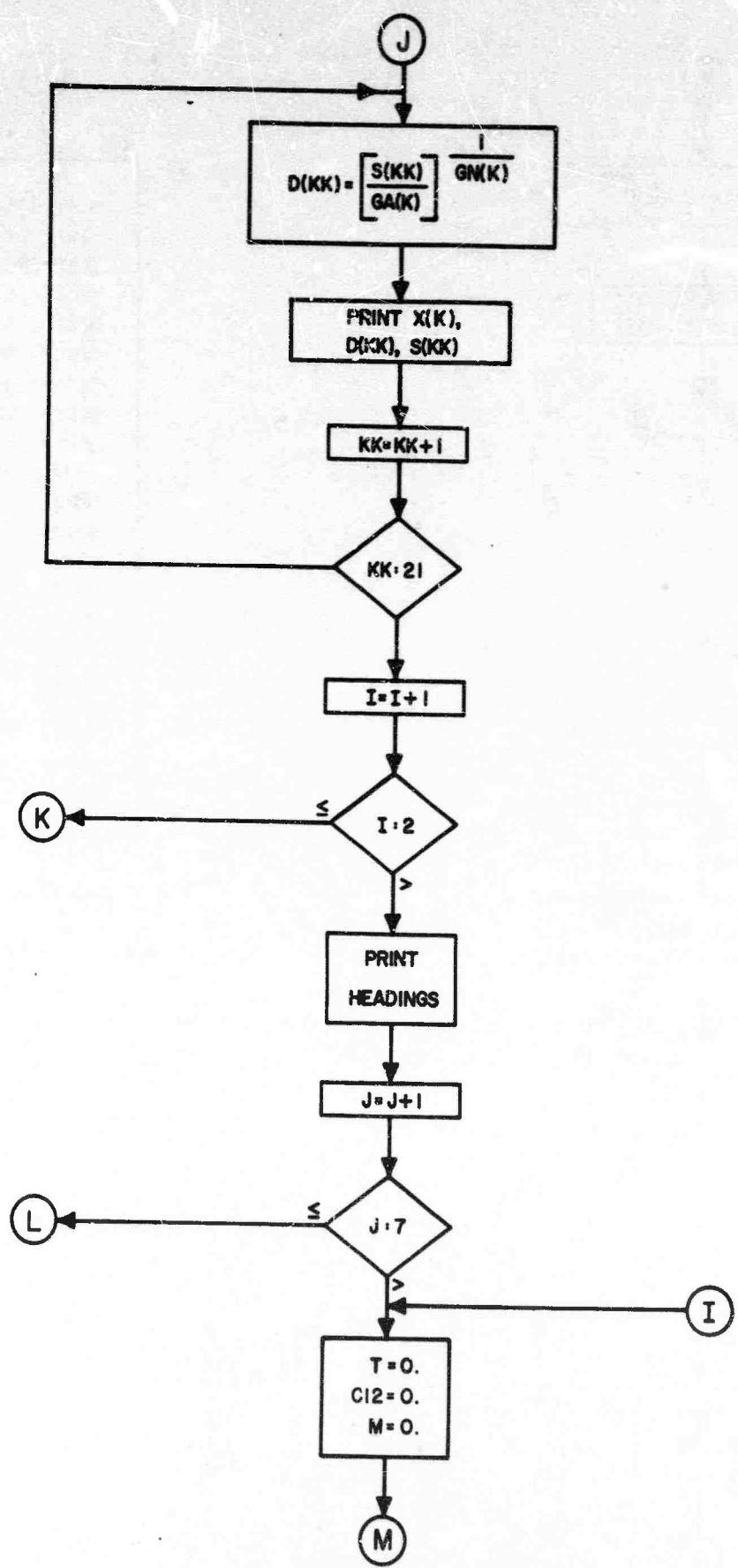


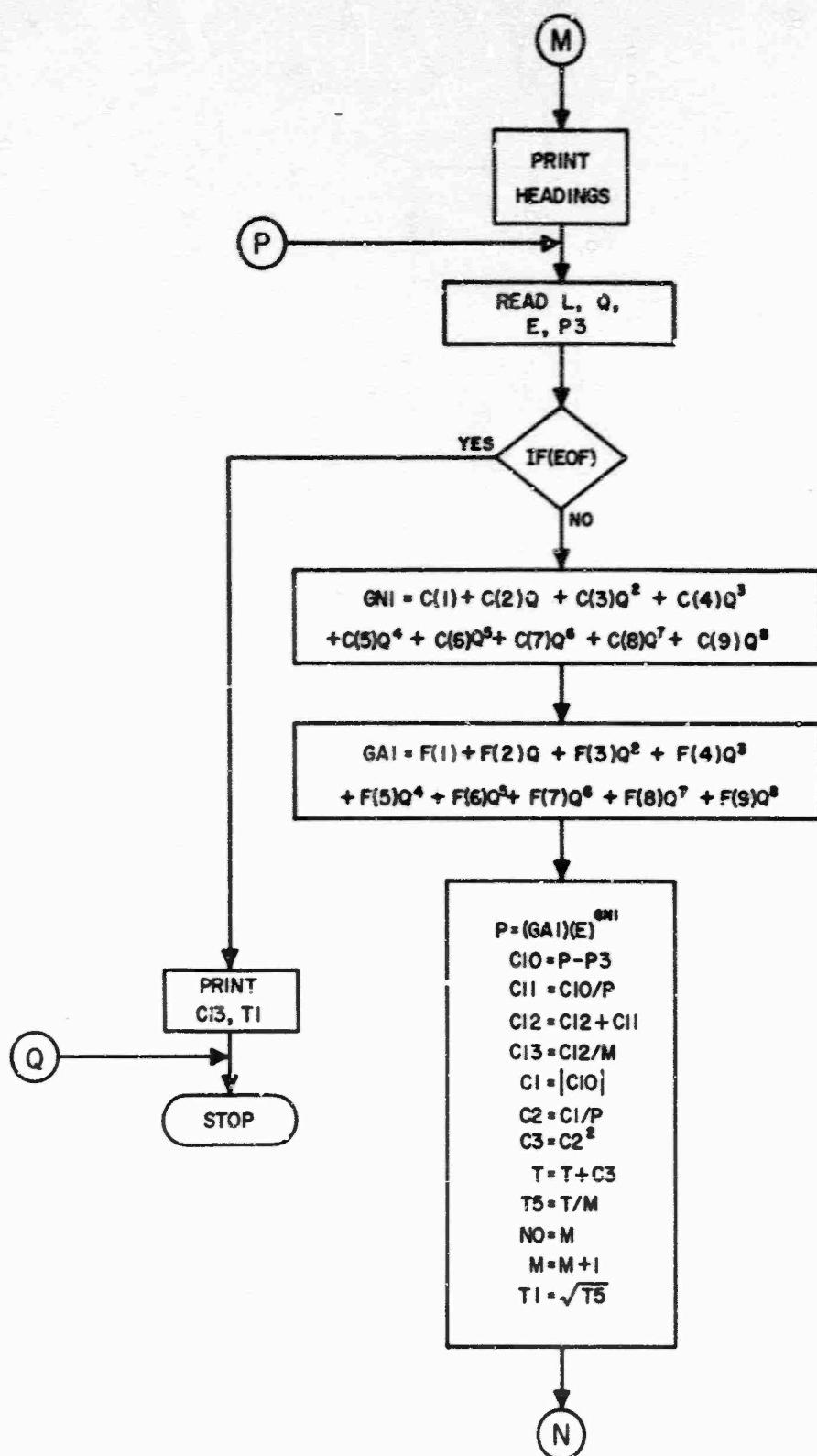


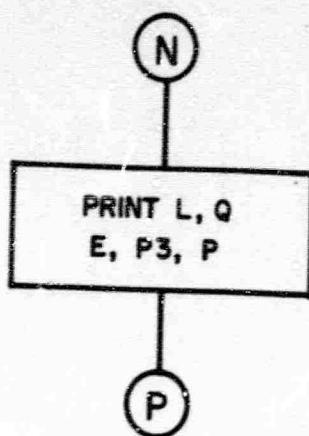












APPENDIX C
EXPERIMENTAL DATA

APPENDIX C

EXPERIMENTAL DATA

Table

- | | |
|------|---|
| C-1 | Experimental Data for 16"/50 Gun |
| C-2 | Experimental Data for 8"/55 Gun |
| C-3 | Experimental Data for 6"/47 Gun |
| C-4 | Experimental Data for 5"/54 Gun |
| C-5 | Experimental Data for 5"/38 Gun |
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| C-9 | Experimental Data for 20 mm M3 Gun |
| C-10 | Experimental Data for 20 mm XM197 Gun |
| C-11 | Experimental Data for 20 mm MARK 12 Gun |

TABLE-C-1

EXPERIMENTAL DATA FOR 16"/50 GUN

ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)
29.90	50.0	15.7
29.90	80.0	6.5
44.50	30.0	22.5
44.70	50.0	15.6
44.80	80.0	8.5
58.60	20.0	27.6
59.00	30.0	20.5
59.50	50.0	10.8
59.70	80.0	4.7
72.10	20.0	15.3
73.50	30.0	13.3
74.40	50.0	6.5
98.50	34.5	6.7
95.10	52.8	4.6
102.40	26.2	10.1
112.30	20.0	8.5
117.00	30.0	5.1
119.00	50.0	2.5
125.00	20.0	5.0
131.20	30.0	2.0
133.80	50.0	1.2
146.70	20.0	3.3
152.50	20.0	2.9
157.70	30.0	1.5
163.20	50.0	1.0

TABLE C-2
EXPERIMENTAL DATA FOR 8"/55 GUN

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>	<u>ARRIVAL TIME (MSEC)</u>	<u>DURATION (MSEC)</u>	<u>IMPULSE (PSI-MSEC)</u>
47.9	15.1	15.93	6.50	4.83	28.17
46.2	27.7	7.17	15.09	7.28	18.95
45.8	40.5	4.32	25.82	6.38	9.60
75.8	15.1	8.12	7.55	3.92	11.74
75.4	27.7	4.34	16.91	5.58	8.69
75.3	40.5	2.70	27.20	5.63	5.54
104.4	15.1	4.68	9.06	3.51	6.05
105.0	27.6	2.39	19.10	4.44	3.89
105.0	40.5	1.56	29.82	6.38	3.64
132.0	15.2	2.60	10.65	3.51	3.38
134.0	27.6	1.42	21.03	4.55	2.38
134.5	40.5	1.44	25.44	4.74	1.78

TABLE C-3
EXPERIMENTAL DATA FOR 6"/47

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>
45.0	25.0	5.84
45.0	39.0	5.08
45.0	50.0	2.38
45.0	100.0	.71
60.0	20.0	7.33
60.0	30.0	4.50
60.0	50.0	1.68
60.0	100.0	.61
75.0	20.0	6.25
75.0	50.0	1.44
75.0	100.0	.60
90.0	20.0	3.91
90.0	30.0	2.60
90.0	50.0	1.39
90.0	100.0	.59
120.0	20.0	2.27
120.0	30.0	1.55
120.0	50.0	.84
120.0	100.0	.35
135.0	20.0	1.37
135.0	30.0	1.16
135.0	50.0	.61
135.0	100.0	.30

TABLE C-4
EXPERIMENTAL DATA FOR 5"/54 GUN

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>	<u>ARRIVAL TIME (MSEC)</u>	<u>DURATION (MSEC)</u>	<u>IMPULSE (PSI-MSEC)</u>
15.0	20	7.2	10.8	7.0	17.0
	30	3.5	18.7	8.0	9.8
	40	2.2	27.2	9.4	7.2
30.0	10	17.0	3.1	3.2	-
	20	6.2	11.4	4.9	14.0
	30	3.4	19.3	6.0	9.8
45.0	40	2.3	27.2	7.5	6.8
	10	14.0	4.64	3.2	18.0
	20	5.5	11.6	5.0	10.0
60.0	30	3.3	18.9	6.0	7.6
	40	2.2	27.2	6.2	5.7
	10	12.0	4.64	3.0	14.0
75.0	20	4.6	12.0	4.1	7.8
	30	2.7	19.6	4.9	5.4
	40	1.9	28.7	5.8	4.5
90.0	10	9.0	4.66	2.2	12.0
	20	3.8	12.6	3.7	6.2
	30	2.2	20.4	4.1	4.2
105.0	40	1.6	28.6	6.0	3.3
	10	6.5	4.64	2.1	5.5
	20	2.8	13.5	3.3	4.2
	30	1.7	21.6	3.2	3.2
	40	1.3	29.4	3.5	2.2
	10	4.1	6.0	2.1	3.6
	20	2.2	13.0	2.6	3.2
	30	1.4	22.1	2.5	1.8

TABLE C-5
EXPERIMENTAL DATA FOR 5"/38 GUN

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>
45.0	13.5	10.30
	17.5	7.27
	22.0	5.43
	25.5	4.67
	30.0	3.65
	37.0	2.59
	39.0	2.10
60.0	8.5	20.43
	12.0	10.07
	14.2	7.70
	15.2	7.90
	18.5	6.07
	21.5	4.60
	22.5	5.00
	26.5	3.20
	8.5	13.05
75.0	10.0	10.65
	13.0	7.05
	14.0	6.10
	33.5	2.20
	4.5	16.35
	6.1	13.50
	7.0	10.03
90.0	10.0	7.40
	14.0	5.08
	18.0	3.53
	25.5	2.00
	27.5	2.10

TABLE C-6

EXPERIMENTAL DATA FOR 3"/50 GUN

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>	<u>ARRIVAL TIME (MSEC)</u>	<u>DURATION (MSEC)</u>	<u>IMPULSE (PSI-MSEC)</u>
48.0	5.7	16.04	2.50	2.18	13.05
46.4	10.4	7.62	5.60	2.99	8.39
46.0	15.2	5.60	9.32	3.16	6.54
75.9	5.7	7.71	2.91	1.95	5.52
75.4	10.4	4.52	6.36	2.36	3.92
75.3	15.2	2.80	10.16	3.00	3.10
104.0	5.7	4.47	3.52	1.68	2.78
105.0	10.4	2.36	7.12	2.43	2.10
105.0	15.2	1.76	11.24	2.90	1.80
131.0	5.8	2.36	4.15	1.43	1.24
133.0	10.4	1.49	7.95	2.05	1.13
134.0	15.2	0.92	12.20	4.14	1.44

TABLE C-7
EXPERIMENTAL DATA FOR 40 MM GUN WITH FLASH HIDER

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>
45.0	3.0	14.96
	7.0	5.70
90.0	15.0	3.28
	3.0	2.52
135.0	7.0	1.82
	15.0	0.92
165.0	3.0	0.38
	7.0	0.20
165.0	15.0	0.10
	3.0	0.18
	7.0	0.10
	15.0	0.06

TABLE C-8

EXPERIMENTAL DATA FOR 40 MM GUN WITHOUT FLASH RIDER

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>
15.0	2.83	25.32
	5.35	6.74
	7.87	5.70
	10.40	3.13
30.0	5.35	8.88
	7.87	4.92
	10.40	3.53
	2.83	20.20
45.0	5.35	7.20
	7.87	5.02
	10.40	3.39
	2.83	15.00
60.0	5.35	7.09
	7.87	4.48
	10.40	2.96
	2.83	12.54
75.0	5.35	4.80
	7.87	3.32
	10.40	2.72
	2.83	8.14
90.0	5.35	3.39
	7.87	2.53
	10.40	1.53
	2.83	4.71
105.0	5.35	2.23
	7.87	1.83
	10.40	1.33
	2.83	3.72
120.0	5.35	1.72
	7.87	1.18
	10.40	0.96
	2.83	2.69
135.0	5.35	1.50
	7.87	0.98
	10.40	0.68
	2.83	1.82
150.0	5.35	1.15
	7.87	0.75
	10.40	0.60
	2.83	1.15
165.0	5.35	0.88
	7.87	0.67
	10.40	0.50

TABLE C-9

EXPERIMENTAL DATA FOR 20 MM M3 GUN

ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)	ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)
15.0	1.0	28.90	195.0	8.0	0.50
	2.0	10.10		10.0	0.40
	4.0	3.40		20.0	0.20
	6.0	1.60	120.0	1.0	3.60
	8.0	1.10		2.0	2.00
	20.0	0.40		5.0	0.70
	30.0	23.60		8.0	0.40
	2.0	9.60		10.0	0.40
	4.0	3.50		20.0	0.20
	6.0	2.00	135.0	1.0	2.50
30.0	8.0	1.50		2.0	1.50
	20.0	0.50		5.0	0.50
45.0	1.0	20.20		8.0	0.30
	2.0	9.00		10.0	0.30
	4.0	3.60		20.0	0.10
	6.0	1.90			
45.0	8.0	1.30			
	20.0	0.50			
60.0	1.0	16.80			
	2.0	8.90			
	4.0	3.20			
	6.0	1.60			
	8.0	1.20			
	20.0	0.40			
75.0	1.0	11.30			
	2.0	5.70			
	4.0	2.40			
	6.0	1.30			
	8.0	1.00			
	20.0	0.40			
90.0	1.0	7.80			
	2.0	4.10			
	4.0	1.80			
	6.0	1.00			
	8.0	0.80			
	20.0	0.30			
105.0	1.0	4.90			
	2.0	2.70			
	5.0	1.00			

TABLE C-10

EXPERIMENTAL DATA FOR 20 MM XM 197 GUN

<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>	<u>ANGLE (DEGREES)</u>	<u>DISTANCE (FEET)</u>	<u>PRESSURE (PSI)</u>
15.0	1.0	34.56	135.0	0.5	3.44
	1.5	24.73		1.5	1.44
	3.0	5.86		3.0	0.78
30.0	10.0	0.94		4.0	0.60
	1.0	23.57		10.0	0.20
	1.5	14.28	150.0	0.5	2.53
	3.0	4.25		1.5	1.03
	4.0	3.80		3.0	0.60
45.0	10.0	0.93		4.0	0.60
	1.0	24.12		10.0	0.20
	1.5	15.46	165.0	0.5	2.00
	3.0	4.02		1.5	1.12
	4.0	3.56		3.0	0.50
60.0	10.0	1.00		4.0	0.60
	0.5	22.22		10.0	0.20
	1.5	9.60			
	3.0	2.98			
	4.0	2.32			
75.0	10.0	0.84			
	0.5	15.34			
	1.5	7.24			
	3.0	2.40			
	4.0	2.18			
90.0	10.0	0.78			
	0.5	10.42			
	1.5	5.08			
	3.0	1.74			
	4.0	1.64			
105.0	10.0	0.40			
	0.5	6.00			
	1.5	3.32			
	3.0	1.37			
	4.0	1.25			
120.0	10.0	0.30			
	0.5	5.60			
	1.5	2.42			
	3.0	0.90			
	4.0	0.82			
	10.0	0.20			

TABLE C-11

EXPERIMENTAL DATA FOR 20 MM MARK 12 GUN

ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)	ANGLE (DEGS.)	DISTANCE (FEET)	PRESSURE (PSI)
0	1.00	30.00	90.0	6.00	1.20
	2.00	16.00		12.00	0.60
	4.00	4.50		20.00	0.30
	6.00	2.10		0.50	7.30
	8.00	1.20		1.50	2.70
	20.00	0.40		3.00	1.90
	3.00	6.90		6.00	1.00
	5.00	3.00		12.00	0.40
	7.00	1.90		20.00	0.20
	10.00	1.00		0.50	5.10
15.0	15.00	0.70	120.0	1.66	2.00
	20.00	0.50		3.00	1.40
	1.00	25.40		6.00	0.60
	2.00	10.80		12.00	0.30
	4.00	4.60		20.00	0.20
	6.00	2.00		0.50	4.20
	8.00	0.90		2.00	1.30
30.0	20.00	0.50	135.0	4.50	0.60
	0.75	23.40		6.00	0.50
	1.75	10.60		10.00	0.30
	3.00	5.60		15.00	0.20
	5.00	2.90		0.50	3.10
	12.00	0.90		2.00	1.10
	20.00	0.50			
45.0	0.50	22.90	150.00		
	1.50	8.00			
	3.00	4.70			
	6.00	1.90			
	12.00	0.30			
	20.00	0.50			
	0.50	14.90			
60.0	1.50	6.00			
	3.00	3.50			
	6.00	1.70			
	12.00	0.60			
	20.00	0.40			
	0.50	11.50			
	1.50	3.80			
75.0	3.00	2.60			
90.0					

APPENDIX D

**COMPUTER GENERATED DATA
FOR CONSTRUCTING CURVES**

APPENDIX D

COMPUTER GENERATED DATA FOR CONSTRUCTING CURVES

Table

- | | |
|------|--|
| D-1 | Free-Air Peak Pressure Data For 16"/50 Gun From Curve Fitting Program |
| D-2 | Free-Air Peak Pressure Data For 8"/55 Gun From Curve Fitting Program |
| D-3 | Free-Air Arrival Time Data For 8"/55 Gun From Curve Fitting Program (preliminary) |
| D-4 | Free-Air Duration Data For 8"/55 Gun From Curve Fitting Program (preliminary) |
| D-5 | Free-Air Impulse Data For 8"/55 Gun From Curve Fitting Program (preliminary) |
| D-6 | Free-Air Peak Pressure Data For 6"/47 Gun From Curve Fitting Program |
| D-7 | Free-Air Peak Pressure Data For 5"/54 Gun From Curve Fitting Program |
| D-8 | Free-Air Arrival Time Data For 5"/54 Gun From Curve Fitting Program (preliminary) |
| D-9 | Free-Air Duration Data For 5"/54 Gun From Curve Fitting Program (preliminary) |
| D-10 | Free-Air Impulse Data For 5"/54 Gun From Curve Fitting Program (preliminary) |
| D-11 | Free-Air Peak Pressure Data For 5"/38 Gun From Curve Fitting Program |
| D-12 | Free-Air Peak Pressure Data For 3"/50 Gun From Curve Fitting Program |
| D-13 | Free-Air Arrival Time Data For 3"/50 Gun From Curve Fitting Program (preliminary) |
| D-14 | Free-Air Duration Data For 3"/50 Gun From Curve Fitting Program (preliminary) |
| D-15 | Free-Air Impulse Data For 3"/50 Gun From Curve Fitting Program (preliminary) |
| D-16 | Free-Air Peak Pressure Data For 40 mm Gun With Flash Hider From Curve Fitting Program |
| D-17 | Free-Air Peak Pressure Data For 40 mm Gun Without Flash Hider From Curve Fitting Program |
| D-18 | Free-Air Peak Pressure Data For 20 mm M3 Gun From Curve Fitting Program |
| D-19 | Free-Air Peak Pressure Data For 20 mm XM197 Gun From Curve Fitting Program |
| D-20 | Free-Air Peak Pressure Data For 20 mm MK 12 Gun From Curve Fitting Program |

TABLE D-1
FREE-AIR PEAK PRESSURE FOR 16" / 50 GUN FROM CURVE FITTING PROGRAM

DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0°		15°		30°		45°		60°		75°		90°		105°		120°		135°		150°		165°	
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)						
2000	0.52	0.67	0.62	0.55	0.45	0.34	0.24	0.19	0.16	0.09	0.03	0.03	0.02	0.02	0.03	0.03	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.03
1000	1.03	1.28	1.05	0.85	0.63	0.45	0.35	0.28	0.18	0.12	0.06	0.03	0.03	0.02	0.02	0.02	0.03	0.06	0.06	0.06	0.05	0.05	0.05	0.03
200	4.90	5.80	4.72	3.71	2.70	1.87	1.40	1.14	0.78	0.31	0.21	0.12	0.06	0.03	0.03	0.03	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.18
100	9.61	11.10	10.80	9.02	7.00	5.04	3.45	2.54	2.07	1.47	0.63	0.36	0.18	0.09	0.05	0.05	0.05	0.09	0.09	0.09	0.08	0.08	0.08	0.06
60	15.80	17.90	17.60	14.50	11.20	8.00	5.42	3.94	3.21	2.36	1.05	0.61	0.31	0.15	0.08	0.05	0.05	0.08	0.08	0.08	0.07	0.07	0.07	0.06
40	23.40	26.30	26.00	21.20	16.20	11.50	7.75	5.59	4.56	3.42	1.58	0.93	0.43	0.21	0.12	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03
30	31.00	34.40	34.20	27.80	21.10	15.00	10.00	7.16	5.84	4.45	2.11	1.26	0.60	0.30	0.16	0.09	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03
20	46.00	50.30	50.30	40.60	30.50	21.60	14.3C	10.10	8.29	6.46	3.17	1.92	0.91	0.46	0.24	0.12	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.03
15	60.80	65.90	66.30	53.10	39.70	28.00	18.50	13.00	10.60	8.41	4.24	3.91	2.59	1.33	0.66	0.33	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.03
10	90.20	96.40	97.70	77.50	57.60	40.40	26.10	18.40	15.10	12.20	6.37	5.92	3.94	2.00	1.00	0.50	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.03
9	100.00	106.00	108.00	85.50	63.40	44.40	29.30	20.20	16.50	13.50	7.09	6.60	4.40	2.20	1.10	0.55	0.27	0.14	0.14	0.14	0.14	0.14	0.14	0.03
8	112.00	119.00	121.00	95.50	70.60	49.40	32.20	22.30	18.30	15.00	7.98	7.44	4.97	2.47	1.23	0.61	0.31	0.16	0.16	0.16	0.16	0.16	0.16	0.03
7	128.00	135.00	137.00	108.00	79.80	55.80	36.20	25.00	20.50	16.90	9.13	8.54	5.71	2.85	1.42	0.71	0.35	0.18	0.18	0.18	0.18	0.18	0.18	0.03
6	148.00	156.00	159.00	125.00	91.80	64.10	41.50	28.60	23.40	19.50	10.70	10.00	6.70	3.35	1.75	0.85	0.42	0.21	0.11	0.05	0.05	0.05	0.05	0.03
5	177.00	185.00	189.00	148.00	109.00	75.60	48.80	33.40	27.40	23.10	12.10	8.10	4.40	2.20	1.10	0.55	0.27	0.14	0.14	0.14	0.14	0.14	0.14	0.03
4	220.00	228.00	234.00	182.00	132.00	92.50	59.40	40.50	33.20	28.30	16.10	15.20	10.20	5.10	2.50	1.25	0.62	0.31	0.16	0.16	0.16	0.16	0.16	0.03
3	291.00	298.00	309.00	239.00	173.00	120.00	76.60	51.90	42.60	36.90	21.50	20.40	13.80	7.10	3.50	1.75	0.85	0.42	0.21	0.11	0.05	0.05	0.05	0.03
2	432.00	437.00	455.00	349.00	251.00	173.00	110.00	73.50	60.40	53.50	32.30	30.90	21.00	10.00	5.00	2.50	1.25	0.62	0.31	0.16	0.16	0.16	0.16	0.03
1	847.00	837.00	882.00	666.00	473.00	324.00	202.00	133.00	110.00	101.00	65.00	62.90	43.10	21.00	10.00	5.00	2.50	1.25	0.62	0.31	0.16	0.16	0.16	0.03
0.5	1660.00	1600.00	1710.00	1270.00	892.00	606.00	374.00	242.00	199.00	191.00	131.00	128.00	88.70	44.00	22.00	11.00	5.50	2.75	1.37	0.68	0.34	0.17	0.17	0.03
0.1	7950.00	7260.00	7960.00	5730.00	3890.00	2590.00	1550.00	968.00	799.00	838.00	662.00	667.00	472.00	21.00	10.00	5.00	2.50	1.25	0.62	0.31	0.16	0.16	0.16	0.03

TABLE D-2
FREE-AIR PEAK PRESSURE DATA FOR E"/55 GUN FROM CURVE FITTING PROGRAM

Pressure (PSI)	DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED						
	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)
2000	0.31	0.32	0.29	0.23	0.14	0.08	0.05
1000	0.54	0.55	0.51	0.40	0.26	0.15	0.10
200	1.93	1.98	2.02	1.82	1.47	1.03	0.65
100	3.34	3.44	3.53	3.16	2.58	1.68	1.22
60	5.00	5.15	5.32	4.75	3.91	2.91	1.93
40	6.88	7.11	7.38	6.56	5.45	4.13	2.79
30	8.64	8.94	9.30	8.25	6.89	5.30	3.62
20	11.90	12.30	12.90	11.40	9.58	7.51	5.23
15	14.90	15.50	16.30	14.30	12.10	9.62	6.78
10	20.50	21.40	22.50	19.80	16.80	13.70	9.78
9	22.30	23.20	24.50	21.50	18.40	14.90	10.80
8	24.50	25.50	27.00	23.60	20.20	16.50	12.00
7	27.20	28.40	30.00	26.30	22.50	18.60	13.50
6	30.80	32.10	34.00	29.70	25.50	21.20	15.50
5	35.50	37.00	39.40	34.30	29.60	24.80	18.30
4	43.30	44.20	47.10	41.00	35.50	30.10	22.40
3	53.10	55.60	59.40	51.60	44.90	38.50	29.10
2	73.20	76.70	82.40	71.20	62.50	54.70	42.00
1	126.00	133.00	144.00	124.00	110.00	99.30	78.60
0.5	218.00	230.00	252.00	215.00	193.00	181.00	147.00
0.1	772.00	826.00	920.00	773.00	717.00	631.00	492.00

Pressure (PSI)	DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED						
	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)	
2000	0.04	0.05	0.04	0.02	0.01	0.01	0.00
1000	0.10	0.15	0.07	0.04	0.01	0.02	0.01
200	0.44	0.65	0.33	0.20	0.07	0.08	0.05
100	1.22	0.83	0.63	0.40	0.15	0.17	0.10
60	1.93	1.33	1.03	0.67	0.27	0.30	0.18
40	2.79	1.94	1.51	1.02	0.43	0.46	0.27
30	3.62	2.53	1.98	1.36	0.59	0.62	0.37
20	5.23	3.67	2.92	2.07	0.92	0.45	0.56
15	6.78	4.80	3.83	2.77	1.27	1.29	0.76
10	9.78	6.97	5.63	4.20	1.99	1.98	1.16
9	13.70	10.80	7.69	6.23	4.68	2.24	2.21
8	14.90	11.40	9.58	7.51	5.23	2.92	2.51
7	16.80	12.10	9.62	7.80	5.33	3.00	2.89
6	19.80	14.30	11.40	9.78	7.10	3.51	3.40
5	22.50	17.00	13.70	11.20	9.16	7.10	1.99
4	24.50	19.50	16.50	13.20	10.90	8.55	4.13
3	27.00	21.50	18.60	15.50	13.50	10.70	5.50
2	30.00	24.50	21.20	18.30	16.30	13.50	5.23
1	34.00	29.70	25.50	21.20	18.30	15.50	7.09
0.5	37.00	34.30	29.60	24.80	21.20	18.30	4.10
0.1	43.30	41.00	35.50	30.10	22.40	16.30	10.90

TABLE D-3
FREE-AIR ARRIVAL TIME DATA FOR 8"/55 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Arrival Time (MSEC)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	913.00	932.00	923.00	915.00	906.00	1090.00	1280.00	1470.00	1590.00	1650.00	1710.00	1750.00	1820.00
1000	560.00	570.00	563.00	556.00	579.00	642.00	731.00	816.00	865.00	887.00	907.00	921.00	950.00
200	180.00	182.00	178.00	174.00	177.00	186.00	198.00	208.00	210.00	209.00	209.00	208.00	212.00
100	111.00	109.00	106.00	106.00	109.00	113.00	113.00	115.00	114.00	112.00	111.00	110.00	111.00
60	77.20	77.20	75.40	73.30	72.80	73.50	74.60	74.60	72.90	70.80	69.50	68.40	66.90
40	58.00	57.90	56.40	54.80	54.00	53.80	53.60	52.80	51.10	49.20	48.00	47.10	47.10
30	47.30	47.20	46.00	44.50	43.70	43.10	42.50	41.30	39.60	38.00	36.90	36.00	36.00
20	35.60	35.40	34.40	33.30	32.40	31.50	30.60	29.30	27.80	26.40	25.50	24.80	24.70
15	29.10	28.90	28.00	27.00	26.20	25.30	24.20	22.20	21.60	20.40	19.60	19.00	18.90
10	21.80	21.60	21.00	20.20	19.40	18.50	17.40	16.20	15.10	14.20	13.50	13.10	12.90
9	20.30	20.10	19.40	18.70	18.00	17.00	16.00	14.80	13.80	12.90	12.30	11.80	11.70
8	18.70	18.50	17.90	17.20	16.50	15.60	14.50	13.40	12.40	11.60	11.00	10.60	10.50
7	17.00	16.80	16.30	15.60	14.90	14.00	13.00	12.00	11.00	10.30	9.78	9.39	9.26
6	15.20	15.10	14.60	14.00	13.30	12.50	11.50	10.50	9.63	8.95	8.50	8.15	8.02
5	13.40	13.20	12.80	12.30	11.60	10.80	9.92	9.01	8.20	7.60	7.19	6.88	6.77
4	11.40	11.30	10.90	10.40	9.88	9.13	8.28	7.45	6.74	6.22	5.87	5.60	5.50
3	9.35	9.20	8.87	8.49	7.99	7.31	6.55	5.83	5.23	4.80	4.51	4.29	4.20
2	7.03	6.90	6.64	6.34	5.93	5.35	4.72	4.13	3.66	3.34	3.12	2.95	2.88
1	4.31	4.22	4.05	3.85	3.56	3.14	2.69	2.29	1.99	1.79	1.66	1.56	1.51
0.5	2.65	2.58	2.47	2.34	2.13	1.84	1.53	1.27	1.08	0.96	0.88	0.82	0.79
0.1	0.85	0.82	0.82	0.78	0.73	0.65	0.53	0.41	0.32	0.23	0.20	0.19	0.18

TABLE D-4
DATA FOR 8" / 55 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

TABLE D-5
FREE-AIR IMPULSE DATA FOR 8"/55 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)
DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Impulse (EGL-MSEC.)	<u>15°</u>						<u>165°</u>					
	<u>0°</u>	<u>30°</u>	<u>45°</u>	<u>60°</u>	<u>75°</u>	<u>90°</u>	<u>105°</u>	<u>120°</u>	<u>135°</u>	<u>150°</u>	<u>165°</u>	
400	0.53	1.03	0.93	0.56	0.25	0.09	0.03	0.011	0.004	0.015	0.007	0.003
300	0.76	1.43	1.29	0.80	0.37	0.14	0.05	0.018	0.007	0.022	0.011	0.004
200	1.25	2.29	2.05	1.32	0.62	0.25	0.10	0.036	0.015	0.038	0.020	0.008
100	2.93	5.12	4.53	3.11	1.56	0.66	0.29	0.123	0.055	0.056	0.052	0.025
60	5.50	9.25	8.13	5.83	3.07	1.36	0.65	0.306	0.139	0.127	0.109	0.057
40	9.05	14.80	12.90	9.60	5.25	2.43	1.23	0.630	0.292	0.243	0.194	0.169
30	12.90	20.60	18.00	13.70	7.69	3.65	1.93	1.050	0.495	0.385	0.292	0.173
20	21.20	33.00	28.60	22.50	13.20	6.49	3.65	2.160	1.040	0.737	0.483	0.333
15	30.20	46.10	39.80	32.10	19.30	9.77	5.73	3.600	1.760	1.170	0.786	0.528
10	49.80	73.60	63.40	52.80	33.00	17.40	10.80	7.110	3.710	2.230	1.400	1.010
9	56.60	83.20	71.50	60.10	37.90	20.20	12.80	8.930	4.500	2.640	1.630	1.200
8	65.50	95.40	81.80	69.50	44.30	23.80	15.40	11.000	5.580	3.190	3.090	1.930
7	77.10	111.00	95.30	81.90	52.90	28.80	19.00	14.000	7.130	3.940	3.710	2.330
6	93.20	133.00	114.00	99.10	64.90	35.70	24.20	18.400	9.460	5.050	4.580	2.910
5	117.00	164.00	140.00	124.00	82.60	46.50	32.30	25.400	13.200	6.750	5.880	3.770
4	153.00	213.00	181.00	163.00	111.00	63.80	45.90	37.800	19.900	9.650	7.970	5.180
3	219.00	297.00	232.00	163.00	96.00	72.10	63.000	33.700	15.300	11.800	7.820	7.030
2	360.00	475.00	400.00	363.00	278.00	171.00	136.00	130.000	70.900	29.200	20.600	13.500
1	844.00	1060.00	886.00	898.00	697.00	457.00	406.00	445.000	253.000	88.500	53.100	31.100
0.5	1980.00	2370.00	1960.00	2110.00	1750.00	1220.00	1210.00	1520.000	900.000	268.000	137.000	101.000
0.1	14300.30	15300.00	12400.00	15300.00	14700.00	12000.00	15200.00	26700.000	17200.000	3510.000	1240.000	1000.000

TABLE D-6

FREE-AIR PEAK PRESSURE DATA FOR 6"/47 GUN FITTING PROGRAM

DISTANCE FROM MUZZLE -- ANGLE FROM MUZZLE AND BORE AXIS EXTENDED

PRESSURF (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.35	0.36	0.35	0.31	0.27	0.20	0.11	0.04	0.02	0.01	0.01	0.01	0.00
1000	0.59	0.61	0.59	0.53	0.46	0.34	0.19	0.08	0.04	0.03	0.02	0.01	0.01
200	1.94	2.00	1.96	1.80	1.57	1.24	0.74	0.36	0.21	0.14	0.10	0.07	0.05
100	3.25	3.35	3.29	3.03	2.67	2.15	1.33	0.68	0.42	0.28	0.20	0.14	0.11
60	4.74	4.89	4.82	4.47	3.95	3.23	2.05	1.09	0.69	0.47	0.34	0.25	0.19
40	6.39	6.60	6.53	6.07	5.40	4.46	2.89	1.58	1.03	0.71	0.52	0.38	0.30
30	7.91	8.17	8.10	7.54	6.73	5.61	3.69	2.06	1.37	0.95	0.71	0.52	0.41
20	10.77	11.03	10.98	10.25	9.19	7.75	5.20	2.98	2.04	1.45	1.08	0.81	0.64
15	13.21	13.65	13.62	12.74	11.47	9.75	6.64	3.88	2.70	1.94	1.45	1.10	0.87
10	17.82	18.43	18.46	17.32	15.66	13.46	9.36	5.62	4.02	2.94	2.22	1.70	1.35
8	19.27	19.93	19.97	18.76	16.98	10.23	10.23	6.19	4.46	3.27	2.48	1.90	1.52
7	21.02	21.74	21.81	20.50	18.59	16.07	11.30	6.90	5.01	3.69	2.80	2.16	1.72
6	23.21	24.01	24.11	22.68	20.66	17.88	12.65	7.80	5.71	4.23	3.22	2.49	1.99
5	26.01	26.91	27.06	25.49	23.18	20.21	14.42	8.98	6.64	4.95	3.78	2.94	2.36
4	29.77	30.80	31.02	29.26	26.67	23.37	16.82	10.61	7.95	5.96	4.57	3.58	2.87
3	35.11	36.34	36.67	34.64	31.66	27.91	20.32	13.01	9.89	7.49	5.77	4.54	3.66
2	43.44	44.97	45.49	43.06	39.49	35.09	25.93	16.93	13.12	10.05	7.78	6.19	5.01
1	58.63	60.73	61.64	58.52	53.92	48.46	36.55	24.54	19.53	15.21	11.87	9.56	7.78
•5	97.91	101.50	103.60	98.86	91.85	84.14	65.72	46.28	38.56	30.68	24.45	20.12	16.51
.1	163.50	169.64	174.15	167.02	156.44	146.09	118.18	87.29	76.14	62.72	50.35	42.33	35.07
537.79	559.00	581.58	564.37	538.71	525.99	461.72	380.86	369.55	324.95	269.35	238.19	201.55	

TABLE D-7
FREE-AIR PRESSURE DATA FOR 5" /54 GUN FROM CURVE FITTING PROGRAM

Pressure (PSI)	Distances from Muzzle -- Angles from Muzzle and Bore Axis Extended												
	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.38	0.52	0.43	0.32	0.25	0.17	0.09	0.03	0.01	0.00	0.00	0.00	0.00
1000	0.60	0.81	0.68	0.52	0.41	0.29	0.17	0.06	0.02	0.01	0.00	0.00	0.00
200	1.79	2.29	1.96	1.61	1.31	0.99	0.62	0.28	0.10	0.06	0.04	0.01	0.01
100	2.87	3.57	3.10	2.62	2.16	1.67	1.09	0.53	0.22	0.14	0.09	0.04	0.02
60	4.06	4.96	4.35	3.75	3.14	2.45	1.66	0.86	0.38	0.26	0.17	0.08	0.04
40	5.35	6.44	5.68	4.98	4.21	3.32	2.32	1.26	0.60	0.42	0.28	0.14	0.08
30	6.50	7.75	6.87	6.09	5.19	4.13	2.93	1.66	0.83	0.59	0.39	0.21	0.13
20	8.55	10.10	8.99	8.08	6.96	5.60	4.09	2.44	1.29	0.97	0.65	0.38	0.25
15	10.40	12.10	10.90	9.89	8.58	6.96	5.18	3.20	1.77	1.36	0.93	0.58	0.38
10	13.70	15.70	14.20	13.10	11.50	9.45	7.22	4.69	2.77	2.21	1.55	1.04	0.72
9	14.70	16.80	15.20	14.10	12.40	10.20	7.87	5.19	3.11	2.51	1.76	1.21	0.85
8	15.90	18.10	16.50	15.30	13.50	11.20	8.67	5.80	3.54	2.89	2.04	1.43	1.02
7	17.40	19.70	18.00	16.90	14.90	12.40	9.67	6.58	4.10	3.39	2.41	1.73	1.25
6	19.40	21.80	19.90	18.80	16.70	13.90	11.00	7.61	4.86	4.08	2.92	2.16	1.59
5	21.90	24.50	22.50	21.30	19.00	15.90	12.70	9.04	5.95	5.07	3.66	2.81	2.11
4	25.50	28.30	26.00	24.90	22.40	18.90	15.30	11.20	7.60	6.62	4.83	3.68	2.99
3	31.00	34.00	31.50	30.50	27.60	23.40	19.40	14.70	10.40	9.35	6.91	5.87	4.68
2	40.80	44.20	41.20	40.50	37.00	31.80	27.00	21.50	16.30	15.20	11.40	10.50	8.78
1	65.20	63.90	65.10	65.70	61.30	53.60	47.70	41.50	35.00	34.80	27.10	28.60	25.80
0.5	104.00	108.00	103.00	107.00	101.00	90.40	84.20	79.90	75.10	79.70	64.10	77.60	75.70
0.1	311.00	303.00	298.00	329.00	304.00	366.00	315.00	442.00	547.00	547.00	788.00	923.00	923.00

TABLE D-8
FREE-AIR ARRIVAL TIME DATA FOR 5" / 54 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)
DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Arrival Time (MSEC)	<u>0°</u>	<u>15°</u>	<u>30°</u>	<u>45°</u>	<u>60°</u>	<u>75°</u>	<u>90°</u>	<u>105°</u>	<u>120°</u>	<u>135°</u>	<u>150°</u>	<u>165°</u>	<u>180°</u>
2000	898.00	914.00	898.00	910.00	957.00	1020.00	1070.00	1100.00	1150.00	1250.00	1360.00	1360.00	1630.00
1000	543.00	554.00	543.00	548.00	570.00	599.00	621.00	633.00	654.00	701.00	749.00	747.00	872.00
200	173.00	174.00	169.00	169.00	171.00	175.00	177.00	177.00	175.00	1	1.00	1.00	203.00
100	106.00	105.00	103.00	102.00	102.00	103.00	103.00	102.00	102.00	103.00	104.00	101.00	108.00
60	73.40	72.90	70.90	69.80	69.50	69.50	69.10	68.00	67.10	67.30	67.40	65.20	58.00
40	55.00	54.40	52.90	51.90	51.30	50.90	50.30	49.30	48.40	48.00	47.60	45.90	47.10
30	44.80	44.20	42.90	42.00	41.40	40.90	40.20	39.20	38.30	37.80	37.20	35.70	36.30
20	33.60	33.00	32.00	31.20	30.60	30.00	29.30	28.50	27.60	26.90	26.30	25.10	25.10
15	27.40	26.80	26.00	25.30	24.60	24.00	23.40	22.60	21.90	21.20	20.60	19.60	19.40
10	20.50	20.00	19.40	18.80	18.20	17.60	17.10	16.40	15.70	15.10	14.50	13.80	13.40
9	19.00	18.50	18.00	17.40	16.80	16.30	15.70	15.10	14.50	13.90	13.30	12.60	12.20
8	17.50	17.00	16.50	16.00	15.40	14.90	14.30	13.80	13.10	12.60	12.00	11.40	10.90
7	15.90	15.50	15.00	14.50	13.90	13.40	12.90	12.40	11.80	11.20	10.70	10.10	9.70
6	14.20	13.80	13.40	12.90	12.40	11.90	11.40	11.00	10.40	9.89	9.39	8.85	8.43
5	12.50	12.10	11.70	11.30	10.80	10.40	9.92	9.48	8.99	8.49	8.04	7.56	7.15
4	10.70	10.30	9.98	9.62	9.17	8.73	8.34	7.94	7.50	7.05	6.64	6.23	5.84
3	8.70	8.40	8.10	7.79	7.40	7.01	6.66	6.32	5.94	5.55	5.19	4.86	4.50
2	6.52	6.27	6.04	5.79	5.46	5.14	4.85	4.58	4.28	3.96	3.67	3.42	3.12
1	3.98	3.80	3.66	3.49	3.25	3.02	2.82	2.64	2.44	2.22	2.03	1.87	1.66
0.5	2.43	2.31	2.22	2.10	1.94	1.78	1.64	1.53	1.39	1.25	1.12	1.03	0.89
0.1	0.77	0.72	0.69	0.65	0.58	0.52	0.47	0.43	0.38	0.33	0.28	0.25	0.21

TABLE D-9
 FREE-AIR DURATION DATA FOR 5"/54 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)
 DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Duration Time (MSEC)	<u>0°</u>	<u>15°</u>	<u>30°</u>	<u>45°</u>	<u>60°</u>	<u>75°</u>	<u>90°</u>	<u>105°</u>	<u>120°</u>	<u>135°</u>	<u>150°</u>	<u>165°</u>	<u>180°</u>
40	1410.00	1260.00	1440.00	1600.00	1510.00	1350.00	1310.00	1260.00	1330.00	1600.00	1470.00	1540.00	
30	735.00	646.00	862.00	748.00	858.00	819.00	837.00	865.00	851.00	906.00	1100.00	1030.00	1100.00
25	486.00	424.00	494.00	581.00	600.00	596.00	630.00	665.00	663.00	712.00	873.00	822.00	887.00
20	293.00	253.00	297.00	359.00	387.00	404.00	444.00	482.00	489.00	530.00	655.00	624.00	683.00
15	153.00	130.00	155.00	143.00	220.00	245.00	284.00	319.00	330.00	362.00	453.00	437.00	487.00
14	131.00	111.00	132.00	166.00	192.00	217.00	255.00	289.00	300.00	331.00	415.00	401.00	449.00
13	111.00	93.20	112.00	141.00	166.00	191.00	227.00	260.00	271.00	300.00	377.00	366.00	412.00
12	92.20	77.40	93.00	119.00	142.00	166.00	200.00	231.00	243.00	270.00	340.00	331.00	375.00
11	75.70	63.30	76.30	98.50	120.00	143.00	175.00	204.00	216.00	240.00	304.00	297.00	339.00
10	61.00	50.70	61.50	80.20	99.30	121.00	151.00	178.00	189.00	212.00	269.00	264.00	303.00
9	48.10	39.80	48.40	63.80	80.80	101.00	128.00	153.00	164.00	184.00	235.00	232.00	268.00
8	36.80	30.30	37.00	49.50	64.10	82.10	106.00	129.00	140.00	158.00	202.00	200.00	233.00
7	27.20	22.20	27.30	37.10	49.30	65.00	86.40	106.00	116.00	132.00	170.00	170.00	199.00
6	19.20	15.50	19.20	26.60	36.50	49.70	68.00	85.30	94.10	108.00	140.00	140.00	166.00
5	12.70	10.20	12.70	17.90	25.50	36.20	51.10	65.60	73.40	84.80	111.00	112.00	134.00
4	7.66	6.08	7.64	11.10	16.40	24.60	36.10	47.60	54.10	63.10	83.10	84.80	103.00
3	3.19	3.12	3.27	5.94	9.35	14.90	23.10	31.40	36.50	43.10	57.50	59.40	73.79
2	1.19	1.22	1.58	2.47	4.22	7.35	12.20	17.50	20.90	25.20	34.20	35.90	45.80
1	0.33	0.25	0.33	0.55	1.08	2.20	4.15	6.47	8.12	10.10	14.00	15.20	20.30
0.5	0.07	0.05	0.07	0.12	0.28	0.66	1.41	2.38	3.14	4.03	5.77	6.45	9.00
0.1	0.00	0.00	0.00	0.01	0.04	0.11	0.24	0.35	0.48	0.73	0.73	0.88	1.36

TABLE D-10
FREE-AIR IMPULSE DATA FOR 5" / 54 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

Angle	Time (sec)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
	400	0.56	1.03	0.58	0.32	0.23	0.14	0.04	0.004	0.001	0.001	0.000	0.000	0.000
	300	0.75	1.34	0.78	0.43	0.31	0.19	0.06	0.006	0.002	0.001	0.000	0.000	0.000
	200	1.13	1.94	1.18	0.68	0.50	0.31	0.10	0.011	0.004	0.002	0.000	0.000	0.000
	100	2.29	3.65	2.39	1.45	1.09	0.72	0.25	0.035	0.015	0.010	0.000	0.000	0.000
	60	3.84	5.83	4.01	2.54	1.95	1.31	0.50	0.082	0.042	0.031	0.000	0.001	0.000
	40	5.79	8.45	6.06	3.98	3.09	2.13	0.87	0.159	0.093	0.074	0.000	0.004	0.001
	30	7.75	11.00	8.11	5.46	4.28	3.00	1.28	0.255	0.165	0.137	0.001	0.010	0.002
	20	11.70	15.90	12.20	8.53	6.78	4.85	2.20	0.496	0.367	0.328	0.002	0.034	0.006
	15	15.70	20.70	16.40	11.70	9.39	6.83	3.25	0.796	0.648	0.608	0.004	0.080	0.013
	10	23.60	30.10	24.70	18.30	14.90	11.10	5.61	1.550	1.440	1.450	0.009	0.274	0.043
	9	26.30	33.10	27.50	20.60	16.80	12.50	6.47	1.840	1.780	1.820	0.012	0.378	0.058
	8	29.60	36.90	31.00	23.40	19.10	14.40	7.58	2.240	2.340	2.340	0.016	0.339	0.082
	7	33.90	41.70	35.50	27.10	22.30	16.90	9.08	2.780	2.920	3.120	0.021	0.808	0.121
	6	39.60	48.00	41.60	32.10	26.50	20.30	11.20	3.590	3.960	4.340	0.030	1.290	0.189
	5	47.70	56.70	50.00	39.30	32.60	25.20	14.30	4.310	5.680	6.420	0.046	2.240	0.321
	4	59.80	69.60	62.70	50.20	42.00	32.90	19.30	6.980	8.820	10.400	0.077	4.400	0.615
	3	80.00	90.50	84.00	68.90	58.20	46.30	28.50	11.200	15.600	19.200	0.148	10.500	1.420
	2	121.00	131.00	127.00	108.00	92.10	75.60	49.20	21.800	34.100	45.900	0.377	35.900	4.630
	1	244.00	247.00	256.00	231.00	202.00	171.00	125.00	66.100	137.000	203.000	1.860	293.000	34.900
	0.5	492.00	467.00	518.00	496.00	413.00	390.00	319.00	213.000	538.000	898.000	9.150	2390.000	263.000
	0.1	2510.00	2040.00	2650.00	2920.00	2750.00	2640.00	2790.00	3000.000	12900.000	20400.000	371.000	2630.000	28500.000

TABLE D-11
FREE-AIR PEAK PRESSURE DATA FOR 5"/38 GUN FROM CURVE FITTING PROGRAM

Pressure (PSI)	DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED							180° (FT)
	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	
2000	0.26	0.34	0.31	0.26	0.21	0.16	0.10	0.04
1000	0.44	0.57	0.51	0.44	0.36	0.27	0.18	0.08
200	1.48	1.80	1.69	1.48	1.23	0.96	0.68	0.45
100	2.49	2.97	2.83	2.50	2.09	1.64	1.19	0.82
60	3.65	4.29	4.13	3.67	3.08	2.44	1.80	1.27
40	4.95	5.74	5.58	4.98	4.19	3.34	2.50	1.79
30	6.14	7.06	6.90	6.19	5.22	4.18	3.16	2.29
20	8.32	9.46	9.32	8.40	7.11	5.74	4.39	3.24
15	10.30	11.50	11.50	10.40	8.85	7.18	5.55	4.14
10	14.00	15.60	15.60	14.20	12.10	9.84	7.71	5.86
9	15.10	16.80	16.80	15.30	13.10	10.70	8.40	6.41
8	16.50	18.30	18.40	16.80	14.30	11.70	9.24	7.09
7	18.30	20.10	20.30	18.50	15.80	13.00	10.30	7.94
6	20.50	22.50	22.70	20.80	17.80	14.70	11.70	9.06
5	23.50	25.70	26.00	23.90	20.40	16.90	13.50	10.60
4	27.80	30.10	30.70	28.30	24.20	20.10	16.20	12.80
3	34.50	37.10	38.00	35.10	30.20	25.10	20.50	16.40
2	46.70	49.70	51.30	47.70	41.10	34.50	28.50	23.20
1	78.60	81.80	85.80	80.50	69.60	59.10	50.00	41.90
0.5	132.00	135.00	143.00	136.00	118.00	101.00	87.70	75.70
0.1	441.00	429.00	473.00	457.00	402.00	355.00	324.00	299.00

	150° (FT)	165° (FT)	180° (FT)
	0.02	0.03	0.01
	0.03	0.05	0.01
	0.08	0.24	0.10
	0.32	0.32	0.07
	0.59	0.45	0.14
	0.93	0.72	0.36
	1.33	1.04	0.39
	1.79	1.04	0.54
	2.29	1.72	0.53
	2.48	1.98	0.82
	3.20	2.58	1.12
	4.20	3.75	1.49
	5.86	4.68	2.26
	6.41	5.58	1.74
	7.25	6.00	2.52
	8.41	7.17	2.52
	9.61	8.48	1.11
	10.30	9.11	0.82
	11.70	10.44	3.27
	13.50	12.51	2.58
	15.30	13.40	1.10
	17.20	16.50	4.20
	19.10	19.30	21.40
	21.00	21.40	49.30
	22.90	23.20	45.50
	24.80	25.10	58.00
	26.10	26.40	238.00
	27.80	28.10	263.00

TABLE D-12
FREE-AIR PEAK PRESSURE DATA FOR 3"/50 GUN FROM CURVE FITTING PROGRAM
DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	165° (FT)	180° (FT)
2000	0.18	0.18	0.19	0.17	0.12	0.07	0.04	0.03	0.02	0.01	0.01	0.01	0.00
1000	0.30	0.30	0.32	0.29	0.21	0.12	0.07	0.05	0.04	0.02	0.01	0.01	0.01
200	0.98	1.00	1.07	0.94	0.71	0.46	0.29	0.21	0.16	0.11	0.06	0.04	0.04
100	1.63	1.68	1.78	1.58	1.20	0.80	0.52	0.38	0.30	0.20	0.12	0.11	0.08
60	2.38	2.45	2.61	2.30	1.78	1.22	0.80	0.59	0.47	0.32	0.20	0.19	0.13
40	3.22	3.31	3.53	3.11	2.42	1.69	1.14	0.84	0.67	0.47	0.30	0.28	0.20
30	3.99	4.10	4.37	3.85	3.02	2.14	1.55	1.08	0.85	0.61	0.40	0.37	0.28
20	5.39	5.55	5.91	5.20	4.12	2.98	2.06	1.54	1.23	0.89	0.60	0.56	0.42
15	6.67	6.87	7.32	6.44	5.14	3.77	2.63	1.98	1.59	1.17	0.80	0.75	0.57
10	9.02	9.28	9.90	8.69	7.01	5.24	3.73	2.82	2.27	1.70	1.19	1.12	0.87
9	9.75	10.00	10.70	9.40	7.60	5.71	4.08	3.10	2.49	1.87	1.32	1.25	0.97
8	10.60	11.00	11.70	10.30	8.32	6.29	4.51	3.43	2.76	2.09	1.49	1.40	1.10
7	11.80	12.10	12.90	11.30	9.21	7.01	5.06	3.85	3.11	2.36	1.70	1.60	1.27
6	13.20	13.60	14.50	12.70	10.40	7.95	5.77	4.41	3.56	2.73	1.98	1.87	1.49
5	15.10	15.50	16.60	14.50	11.90	9.22	6.74	5.17	4.19	3.23	2.37	2.25	1.80
4	17.80	18.30	19.60	17.10	14.10	11.10	8.16	6.27	5.10	3.97	2.96	2.81	2.28
3	22.00	22.70	24.30	21.20	17.60	14.00	10.40	8.06	6.57	5.18	3.93	3.75	3.08
2	29.80	30.70	32.80	28.60	24.00	19.40	14.80	11.50	9.40	7.55	5.88	5.62	4.70
1	49.80	51.40	55.00	47.90	40.90	34.20	26.80	21.00	17.30	14.30	11.70	11.20	9.72
0.5	83.40	86.00	92.10	80.00	69.50	60.20	48.40	38.40	32.00	27.30	23.30	22.50	20.10
0.1	275.00	284.00	305.00	264.00	239.00	223.00	192.00	156.00	133.00	121.00	115.00	113.00	109.00

TABLE D-13
 FREE-AIR ARRIVAL TIME DATA FOR 3"/50 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)
 DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Arrival Time (MSEC)	<u>0°</u>	<u>15°</u>	<u>30°</u>	<u>45°</u>	<u>60°</u>	<u>75°</u>	<u>90°</u>	<u>105°</u>	<u>120°</u>	<u>135°</u>	<u>150°</u>	<u>165°</u>	<u>180°</u>
2000	841.00	845.00	842.00	871.00	946.00	1090.00	1310.00	1520.00	1610.00	1620.00	1740.00	1730.00	
1000	504.00	505.00	501.00	514.00	551.00	620.00	720.30	816.00	854.00	855.00	905.00	899.00	
200	153.00	154.00	153.00	150.00	151.00	156.00	166.00	181.00	194.00	196.00	193.00	199.00	197.00
160	91.90	92.10	91.20	89.40	89.00	90.60	94.20	99.60	104.00	104.00	102.00	104.00	103.00
60	63.00	63.00	62.40	61.00	60.30	60.70	62.00	64.20	66.00	65.40	63.70	64.00	63.30
40	46.70	46.60	46.10	45.00	44.30	44.20	44.50	45.30	45.90	45.20	43.80	43.70	43.20
30	37.70	37.60	37.20	36.30	35.60	35.20	35.20	35.40	35.50	34.70	33.60	33.40	33.00
20	28.00	27.80	27.60	26.80	26.10	25.60	25.20	25.00	24.70	24.00	23.10	22.80	22.50
15	22.60	22.50	22.20	21.60	21.00	20.50	19.90	19.50	19.10	18.40	17.70	17.40	17.10
10	16.80	16.60	16.50	15.90	15.40	14.90	14.30	14.30	13.80	13.30	12.70	12.20	11.70
9	15.50	15.40	15.20	14.70	14.20	13.70	13.10	12.50	12.10	11.60	11.00	10.70	10.60
8	14.20	14.10	13.90	13.50	13.00	12.50	11.90	11.40	10.90	10.40	9.91	9.61	9.48
7	12.90	12.80	12.60	12.20	11.80	11.30	10.70	10.10	9.66	9.19	8.76	8.48	8.36
6	11.50	11.40	11.30	10.90	10.50	9.98	9.43	8.89	8.42	7.98	7.60	7.33	7.23
5	10.00	9.94	9.83	9.48	9.10	8.65	8.12	7.60	7.15	6.76	6.42	6.17	6.09
4	8.51	8.42	8.33	8.02	7.68	7.26	6.77	6.27	5.86	5.51	5.23	5.00	4.93
3	6.88	6.80	6.72	6.47	6.17	5.80	5.35	4.90	4.53	4.24	4.01	3.82	3.76
2	5.10	5.03	4.97	4.77	4.53	4.22	3.84	3.46	3.15	2.93	2.76	2.61	2.57
1	3.06	3.01	2.97	2.84	2.67	2.45	2.18	1.91	1.70	1.55	1.45	1.36	1.33
0.5	1.83	1.80	1.77	1.69	1.58	1.42	1.23	1.05	0.91	0.83	0.77	0.71	0.69
0.1	0.56	0.54	0.51	0.46	0.40	0.33	0.26	0.22	0.19	0.17	0.16	0.15	

TABLE D-14
FREE-AIR DURATION DATA FOR 3"/50 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)
DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Duration Time (MSEC)	<u>15°</u>							<u>180°</u>							
	<u>0°</u>	<u>30°</u>	<u>45°</u>	<u>60°</u>	<u>75°</u>	<u>90°</u>	<u>105°</u>	<u>120°</u>	<u>135°</u>	<u>150°</u>	<u>165°</u>	<u>180°</u>			
4.0	2150.00	2080.00	1900.00	1700.00	1500.00	1280.00	1040.00	2270.00	2510.00	2750.00	3000.00	3290.00	3560.00	3670.00	4000.00
3.0	1220.00	1170.00	1070.00	1000.00	950.00	895.00	802.00	1570.00	1710.00	1880.00	2050.00	2150.00	2370.00		
2.5	846.00	814.00	748.00	745.00	745.00	895.00	998.00	1100.00	1190.00	1320.00	1450.00	1530.00	1700.00		
2.0	543.00	521.00	480.00	480.00	478.00	515.00	576.00	644.00	727.00	771.00	851.00	943.00	1010.00	1130.00	
1.5	307.00	294.00	271.00	270.00	270.00	326.00	366.00	403.00	439.00	486.00	543.00	590.00	669.00		
1.4	267.00	256.00	236.00	235.00	235.00	284.00	320.00	352.00	383.00	424.00	476.00	519.00	590.00		
1.3	231.00	221.00	204.00	203.00	203.00	218.00	246.00	261.00	304.00	331.00	367.00	413.00	452.00	515.00	
1.2	197.00	188.00	174.00	173.00	173.00	186.00	210.00	236.00	260.00	283.00	314.00	354.00	389.00	445.00	
1.1	165.00	158.00	146.00	145.00	145.00	157.00	177.00	199.00	219.00	239.00	265.00	300.00	331.00	380.00	
1.0	137.00	131.00	121.00	120.00	120.00	130.00	146.00	165.00	182.00	198.00	220.00	250.00	277.00	319.00	
0.9	111.00	106.00	98.20	97.50	97.50	105.00	119.00	134.00	148.00	161.00	179.00	204.00	228.00	263.00	
0.8	87.80	83.70	77.70	77.10	77.10	83.10	94.10	107.00	118.00	128.00	142.00	163.00	183.00	212.00	
0.7	67.40	64.20	59.60	59.10	59.10	63.70	72.20	82.00	90.50	98.50	110.00	126.00	143.00	167.00	
0.6	49.60	47.20	43.90	43.50	43.50	46.90	53.30	60.60	66.90	72.80	81.20	93.80	107.00	126.00	
0.5	34.50	32.80	30.60	30.20	30.20	32.60	37.10	42.40	46.80	50.90	56.90	66.10	76.10	90.10	
0.4	22.10	21.00	19.60	19.40	19.40	20.90	23.90	27.30	30.20	32.90	36.80	43.10	50.20	60.00	
0.3	12.50	11.80	11.10	10.90	10.90	11.80	13.50	13.50	17.20	18.70	21.00	24.80	29.40	32.50	
0.2	5.58	5.27	4.95	4.88	5.27	6.07	6.07	7.78	8.44	9.51	11.40	13.80	16.90		
0.1	1.41	1.32	1.25	1.23	1.33	1.54	1.54	2.00	2.17	2.46	3.02	3.79	4.78		
0.5	0.35	0.33	0.32	0.31	0.31	0.33	0.39	0.51	0.56	0.63	0.80	1.01	1.35		
0.1					0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.05		

TABLE D-15
FREE-AIR IMPULSE DATA FOR 3"/50 GUN FROM CURVE FITTING PROGRAM (PRELIMINARY)

DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Impulse (PSI-MSEC)	<u>0°</u>	<u>15°</u>	<u>30°</u>	<u>45°</u>	<u>60°</u>	<u>75°</u>	<u>90°</u>	<u>105°</u>	<u>120°</u>	<u>135°</u>	<u>150°</u>	<u>165°</u>	<u>180°</u>	
2000	0.013	0.033	0.044	0.026	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1000	0.020	0.049	0.051	0.066	0.038	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
200	0.037	0.085	0.094	0.114	0.067	0.011	0.000	0.000	0.000	0.001	0.001	0.000	0.000	
100	0.108	0.219	0.267	0.291	0.178	0.037	0.002	0.001	0.001	0.003	0.002	0.000	0.000	
60	0.235	0.439	0.577	0.581	0.365	0.094	0.007	0.003	0.008	0.006	0.001	0.000	0.000	
40	0.438	0.762	1.060	1.010	0.645	0.195	0.019	0.008	0.018	0.012	0.003	0.000	0.000	
30	0.680	1.130	1.640	1.490	0.965	0.328	0.039	0.016	0.031	0.020	0.005	0.000	0.000	
20	1.270	1.960	3.030	2.580	1.700	0.684	0.102	0.041	0.068	0.042	0.011	0.000	0.000	
15	1.970	2.890	4.670	3.800	2.550	1.150	0.203	0.080	0.118	0.070	0.019	0.000	0.000	
10	3.660	5.030	8.610	6.590	4.510	2.400	0.536	0.206	0.254	0.146	0.044	0.000	0.000	
9	4.300	5.800	10.100	7.600	5.220	2.900	0.690	0.264	0.311	0.177	0.054	0.000	0.000	
8	5.140	6.810	12.000	8.920	6.160	3.600	0.915	0.347	0.389	0.219	0.069	0.000	0.000	
7	6.310	8.170	14.700	10.700	7.430	4.600	1.260	0.474	0.502	0.278	0.090	0.000	0.000	
6	7.990	10.100	18.600	13.200	9.230	6.050	1.820	0.679	0.673	0.368	0.122	0.000	0.000	
5	10.600	12.900	24.500	16.900	11.900	8.420	2.820	1.040	0.953	0.511	0.177	0.000	0.000	
4	14.900	17.500	34.300	22.800	16.300	12.600	4.810	1.750	1.460	0.765	0.277	0.000	0.000	
3	23.100	25.900	52.900	33.700	24.400	21.200	9.580	3.420	2.520	1.290	0.494	0.000	0.000	
2	42.900	44.900	97.500	58.400	43.100	44.300	25.300	8.810	5.460	2.680	1.120	0.000	0.000	
1	124.000	115.000	277.000	149.000	114.000	155.000	133.000	44.400	20.400	9.350	4.500	0.000	0.000	
0.5	358.000	246.000	788.000	382.000	301.000	545.000	699.000	224.000	76.500	32.700	18.200	0.000	0.000	
0.1	4210.000	2650.000	8930.000	3340.000	2860.000	33000.000	9550.000	1640.000	599.000	164.000	59.000	16.400	0.000	0.000

TABLE D-16
FREE-AIR PEAK PRESSURE FOR 40 MM GUN WITH FLASH HIDER FROM CURVE FITTING PROGRAM

Pressure (PSI)	Distances from Muzzle -- Angles from Muzzle and Bore Axis Extended										180° (FT)
	0° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	105° (FT)	120° (FT)	135° (FT)	150° (FT)	
0°	0.04	0.023	0.017	0.011	0.006	0.002	0.006	0.002	0.001	0.000	0.0000
15°	0.08	0.047	0.035	0.023	0.012	0.004	0.001	0.005	0.002	0.001	0.0000
30°	0.36	0.32	0.240	0.185	0.129	0.067	0.024	0.0090	0.0037	0.0015	0.0004
45°	0.70	0.63	0.488	0.383	0.269	0.144	0.053	0.0202	0.0086	0.0035	0.0008
60°	1.14	1.03	0.821	0.652	0.453	0.251	0.094	0.0365	0.0161	0.0064	0.0014
75°	1.52	1.47	1.240	0.996	0.712	0.391	0.148	0.0584	0.0265	0.0103	0.0023
90°	2.00	1.660	1.350	0.966	0.535	0.205	0.0815	0.0377	0.0144	0.0032	0.0002
105°	2.19	2.00	1.660	1.350	0.966	0.535	0.205	0.0815	0.0377	0.0144	0.0002
120°	2.22	2.05	1.720	1.490	1.140	0.783	0.325	0.1310	0.0621	0.0233	0.0051
135°	2.370	2.160	1.870	1.610	1.210	0.833	0.325	0.1310	0.0621	0.0233	0.0051
150°	2.69	2.43	2.100	1.780	1.140	0.450	0.1820	0.0886	0.0327	0.0070	0.0164
165°	5.75	6.21	4.240	3.100	1.780	0.712	0.2920	0.1460	0.0528	0.0111	0.0270
180°	6.86	9	5.680	4.730	3.460	1.990	0.803	0.3300	0.1660	0.0598	0.0125
180°	7.67	8	6.400	5.350	3.930	2.270	0.917	0.3780	0.1920	0.0687	0.0143
180°	8.71	7	7.340	6.160	4.520	2.620	1.070	0.4420	0.2260	0.0805	0.0166
180°	9.40	10.12	8.590	7.230	5.330	3.100	1.270	0.5280	0.2740	0.0966	0.0198
180°	12.00	12.00	10.300	8.750	6.460	3.790	1.560	0.6530	0.3420	0.1200	0.0244
180°	13.90	14.80	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	14.30	14.40	12.300	10.400	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	14.80	15.40	13.300	11.100	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	15.40	16.30	14.900	12.400	9.500	5.600	2.100	0.7530	0.3820	0.1300	0.0244
180°	16.30	17.00	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	17.00	17.80	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	17.80	18.50	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	18.50	19.40	13.300	11.100	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	19.40	20.30	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	20.30	21.20	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	21.20	22.00	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	22.00	22.80	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	22.80	23.50	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	23.50	24.30	13.300	11.100	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	24.30	25.10	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	25.10	26.00	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	26.00	26.80	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	26.80	27.50	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	27.50	28.30	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	28.30	29.10	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	29.10	29.90	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	29.90	30.70	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	30.70	31.50	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	31.50	32.30	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	32.30	33.10	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	33.10	33.90	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	33.90	34.70	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	34.70	35.50	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	35.50	36.30	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	36.30	37.10	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	37.10	37.90	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	37.90	38.70	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	38.70	39.50	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	39.50	40.30	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	40.30	41.10	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	41.10	41.90	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	41.90	42.70	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	42.70	43.50	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	43.50	44.30	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	44.30	45.10	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	45.10	45.90	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	45.90	46.70	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	46.70	47.50	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	47.50	48.30	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	48.30	49.10	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	49.10	49.90	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	49.90	50.70	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	50.70	51.50	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	51.50	52.30	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	52.30	53.10	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	53.10	53.90	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	53.90	54.70	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	54.70	55.50	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	55.50	56.30	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	56.30	57.10	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	57.10	57.90	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	57.90	58.70	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	58.70	59.50	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	59.50	60.30	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	60.30	61.10	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	61.10	61.90	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	61.90	62.70	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	62.70	63.50	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	63.50	64.30	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	64.30	65.10	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	65.10	65.90	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	65.90	66.70	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	66.70	67.50	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	67.50	68.30	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	68.30	69.10	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	69.10	69.90	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	69.90	70.70	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	0.0244
180°	70.70	71.50	13.000	11.000	8.190	4.830	2.010	0.8460	0.4510	0.1560	0.0314
180°	71.50	72.30	12.800	10.300	7.500	4.100	1.500	0.6530	0.3420	0.1200	

TABLE D-17
FREE-AIR PEAK PRESSURE FOR 40 MM GUN WITHOUT FLASH HIDER FROM CURVE FITTING PROGRAM

PRESSURE (PSI)	DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED						
	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)
2000	0.15	0.14	0.12	0.10	0.08	0.05	0.03
1000	0.24	0.23	0.20	0.17	0.13	0.09	0.05
200	0.71	0.68	0.62	0.54	0.43	0.31	0.18
100	1.14	1.10	1.01	0.89	0.73	0.53	0.33
60	1.61	1.56	1.44	1.29	1.08	0.80	0.51
40	2.12	2.05	1.92	1.73	1.46	1.11	0.72
30	2.57	2.50	2.35	2.13	1.82	1.39	0.92
20	3.39	3.30	3.12	2.86	2.47	1.92	1.30
15	4.11	4.02	3.82	3.52	3.07	2.42	1.65
10	5.41	5.30	5.07	4.72	4.16	3.34	2.34
9	5.81	5.70	5.46	5.09	4.51	3.63	2.56
8	6.29	6.18	5.93	5.54	4.93	3.99	2.83
7	6.88	6.77	6.52	6.11	5.45	4.44	3.17
6	7.64	7.53	7.26	6.83	6.12	5.02	3.61
5	8.64	8.53	8.25	7.79	7.03	5.81	4.22
4	10.04	9.94	9.64	9.15	8.32	6.94	5.10
3	12.20	12.10	11.80	11.27	10.33	8.73	6.51
2	16.05	15.97	15.68	15.11	14.03	12.05	9.20
1	25.63	25.67	25.49	24.95	23.67	20.95	16.59
.5	40.94	41.27	41.44	41.20	39.94	36.39	29.94
.1	121.46	124.26	128.05	131.97	134.55	131.27	117.80

150°

(FT)

135°

(FT)

120°

(FT)

105°

(FT)

90°

(FT)

75°

(FT)

60°

(FT)

45°

(FT)

30°

(FT)

15°

(FT)

0°

(FT)

165°

(FT)

150°

(FT)

135°

(FT)

120°

(FT)

105°

(FT)

90°

(FT)

75°

(FT)

60°

(FT)

45°

(FT)

30°

(FT)

15°

(FT)

0°

(FT)

TABLE D-18
FREE-AIR PEAK PRESSURE DATA FOR 20 MM M3 GUN FROM CURVE FITTING PROGRAM

TABLE D-19
FREE-AIR PEAK PRESSURE DATA FOR 20 MM XM197 GUN FROM CURVE FITTING PROGRAM

Pressure (PSI)	DISTANCES FROM MUZZLE — ANGLES FROM MUZZLE AND BORE AXIS EXTENDED							165° (FT)
	0° (FT)	15° (FT)	30° (FT)	45° (FT)	60° (FT)	75° (FT)	90° (FT)	
2000	0.070	0.098	0.055	0.015	0.007	0.004	0.002	0.0006
1000	0.112	0.150	0.014	0.027	0.013	0.008	0.002	0.0004
200	0.326	0.400	0.235	0.108	0.058	0.037	0.021	0.0014
100	0.517	0.611	0.388	0.196	0.112	0.074	0.044	0.0008
60	0.727	0.834	0.550	0.304	0.182	0.122	0.075	0.0003
40	0.952	1.070	0.749	0.430	0.267	0.183	0.115	0.0027
30	1.150	1.270	0.921	0.549	0.350	0.244	0.155	0.0044
20	1.510	1.630	1.230	0.777	0.513	0.364	0.239	0.0061
15	1.830	1.950	1.520	0.995	0.673	0.485	0.324	0.0043
10	2.400	2.490	2.030	1.410	0.987	0.726	0.497	0.0090
9	2.570	2.660	2.190	1.540	1.090	0.806	0.556	0.0113
8	2.780	2.860	2.380	1.700	1.220	0.906	0.629	0.0077
7	3.040	3.100	2.620	1.910	1.380	1.030	0.725	0.0099
6	3.370	3.410	2.930	2.180	1.690	1.210	0.853	0.0163
5	3.810	3.810	3.340	2.550	1.900	1.450	1.030	0.0250
4	4.420	4.360	3.920	3.080	2.340	1.800	1.310	0.0300
3	5.350	5.200	4.820	3.940	3.070	2.400	1.780	0.03420
2	7.010	6.670	6.450	5.580	4.500	3.590	2.730	0.05200
1	11.100	10.200	10.600	10.100	8.660	7.200	5.680	0.55800
0.5	17.700	15.500	17.500	18.300	16.700	14.300	11.800	0.34900
00.1	51.600	41.600	55.600	72.500	76.100	70.600	65.000	0.25300

135°
(FT)

120°
(FT)

105°
(FT)

90°
(FT)

75°
(FT)

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TABLE D-20
FREE-AIR PEAK PRESSURE DATA FOR 20 NM MK 12 GUN FROM CURVE FITTING PROGRAM
DISTANCES FROM MUZZLE -- ANGLES FROM MUZZLE AND BORE AXIS EXTENDED

Pressure (PSI)	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)
2000	0.08	0.05	0.036	0.027	0.022	0.016	0.009	0.004	0.002	0.001	0.0002	0.0001	0.0000
1000	0.12	0.08	0.060	0.046	0.029	0.013	0.006	0.0030	0.0019	0.0011	0.0005	0.0002	0.0001
200	0.35	0.25	0.206	0.164	0.111	0.060	0.030	0.0168	0.0111	0.0068	0.0033	0.0017	0.0007
100	0.55	0.41	0.349	0.283	0.190	0.116	0.061	0.0355	0.0236	0.0148	0.0077	0.0041	0.0020
60	0.76	0.60	0.515	0.424	0.306	0.187	0.104	0.0616	0.0411	0.0262	0.0143	0.0080	0.0040
40	0.99	0.81	0.701	0.583	0.430	0.273	0.157	0.0953	0.0640	0.0414	0.0233	0.0136	0.0071
30	1.19	1.09	0.99	0.873	0.731	0.548	0.357	0.211	0.1300	0.0876	0.0571	0.0329	0.0198
20	1.54	1.33	1.190	1.010	0.772	0.522	0.321	0.2010	0.1360	0.0901	0.0537	0.0335	0.0187
15	1.85	1.64	1.480	1.260	0.984	0.684	0.431	0.2740	0.1870	0.1250	0.0760	0.0487	0.0281
10	2.40	2.20	2.020	1.730	1.390	1.000	0.654	0.4240	0.2900	0.1960	0.1240	0.0825	0.0496
9	2.57	2.38	2.190	1.980	1.510	1.100	0.729	0.4750	0.3260	0.2210	0.1410	0.0945	0.0575
8	2.77	2.59	2.390	2.070	1.670	1.230	0.823	0.5400	0.3700	0.2520	0.1620	0.1100	0.0679
7	3.02	2.85	2.650	2.300	1.870	1.400	0.944	0.6230	0.4280	0.2930	0.1910	0.1310	0.0819
6	3.33	3.19	2.980	2.590	2.130	1.610	1.110	0.7360	0.5070	0.3480	0.2300	0.1600	0.1020
5	3.75	3.64	3.420	2.990	2.490	1.910	1.340	0.8950	0.6180	0.4280	0.2860	0.2030	0.1310
4	4.33	4.28	4.050	3.560	3.000	2.360	1.680	1.1400	0.7880	0.5490	0.3740	0.2710	0.1800
3	5.20	5.28	5.050	4.470	3.830	3.090	2.260	1.5500	1.0800	0.7590	0.5300	0.3940	0.2690
2	6.75	7.08	6.880	6.150	5.390	4.510	3.430	2.4000	1.6800	1.2000	0.8640	0.6680	0.4760
1	10.50	11.70	11.700	10.600	9.670	8.640	6.990	5.0700	3.5800	2.6100	1.9900	1.6400	1.2600
0.5	16.40	19.40	19.800	18.300	17.300	16.500	14.300	10.7000	7.6100	5.6800	4.6000	3.4000	2.4000
0.1	46.20	62.30	67.400	64.900	67.400	74.700	74.800	60.5000	44.0000	34.6000	32.7000	32.1000	32.0000

APPENDIX E

STATISTICAL DATA

APPENDIX E

STATISTICAL DATA

Table

E-1 Statistical Data Comparing Experimental And Computer Generated
Values

TABLE E-1
STATISTICAL DATA COMPARING EXPERIMENTAL AND COMPUTER GENERATED VALUES

Table shows first and square root of the second moment in percent

GUN	FIRST (%)	PRESSURE		ARRIVAL		DURATION		IMPULSE	
		FIRST (%)	SECOND (%)	FIRST (%)	SECOND (%)	FIRST (%)	SECOND (%)	FIRST (%)	SECOND (%)
16"/50	11	24	-	6	-	-	-	-	-
8"/55	-3	15	2	-	-3	17	-	-3	19
6"/47	+3	15	-	-	-	-	-	-	-
5"/54	0	4	-5	6	7	9	-4	-4	16
5"/38	0	11	-	-	-	-	-	-	-
3"/50	0	15	1	1	-1	21	-10	-10	29
40 MM *	-	-	-	-	-	-	-	-	-
40 MM **	5	14	-	-	-	-	-	-	-
20 MM M 3	-8	21	-	-	-	-	-	-	-
20 MM									
XM197	-9	33	-	-	-	-	-	-	-
20 MM									
MK 12	2	14	-	-	-	-	-	-	-

* 40 MM WITH FLASH HIDER (NOT AVAILABLE)

** 40 MM WITHOUT FLASH HIDER

APPENDIX F

FIRING TEST DATA

Table

F-1 Firing Test Data for Enclosed Guns

TABLE F-1
FIRING TEST DATA

GUN	16" / 50	16" / 55	6" / 17	5" / 54	5" / 38	3" / 50	40 mm	20 mm M3*	20 mm MK 12*
BARREL, MARK-MOD	N.A.	15-7	16-0	18-0	12-1	N.A.	1-0	3-0	12-0
PROJECTILE MARK-MOD	N.A.	25	36	41	49	33	2	99	55A2
WEIGHT (LBS)	N.A. N.A.	335	130	70.0	55.18	13.0	1.985	.271	.214 .243
PROPELLANT TYPE	N.A.	MACO	M-1	PYRO	M-1	M-6	N.A.	PYRO(DNT COATED)	
INDEX C. ARGE (LBS)	N.A. N.A.	SPCP-11072 98.17	SPDN-9744 33.79	SPDN-9733 18.38	SPDN-7380 15.83	SPDN-9744 4.06	SPDN-8927 .687	N.A. .07	SPDN-10802 .C915
DATE	1967-68	Sept 69	July 68	May, June	May, April	Sept 69	Apr 71** May 71***	Nov, Dec 66	Oct 69 Nov, Dec 66

N.A. - Not Available
 * - Fired Without Diffuser
 ** - With Flash Hider
 *** - Without Flash Hider

Distribution
Nat Shot

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body or abstract and indexing annotation must be entered when the overall report is classified)

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13. ABSTRACT The available data on gun blasts from naval guns are compiled utilizing computer curve fitting techniques. Curves of peak free-air pressure are presented for all naval guns, ranging in size from 20mm to 16"/50. In addition, curves of arrival time, duration and impulse are given for three of these guns. Development of the computer programs and data reduction methods which were used to model the free-air gun blast field are described.		